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THE APPLICATION OF COST/BENEFIT ANALYSIS IN THE DEVELOPMENT OF VOLUNTARY STANDARDS

by

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The Application of Cost/Benefit Analysis in the Development of Voluntary Standards

by

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ABSTRACT

The purpose of this ~~study~~ thesis is to investigate the role and significance of standards to industry and society from an economic perspective. The decisionmaking processes of voluntary standards organizations, such as the American National Standards Institute are examined within a framework of applied economic cost/benefit analysis. The findings of the study emphasize the need for non-engineering evaluation of standards and standardizing activities within single firms, industrywide organizations, or government.

Keywords: Specifications, Standardization

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I. INTRODUCTION

The intention of this study is to investigate the cost-benefit analysis methods used in the creation of voluntary standards. Economic evaluation was undertaken through a comprehensive review of the history and evolution of nongovernmental standards and the current operating regulations of the major standards organizations. The study is based upon the assumption that a voluntary standard, although not complying with the strict definition of the term, is a public good. As with other public goods, decisions for their creation and the amount offered for public consumption are essentially economic. The object, therefore, of the investigation is to determine from an economic perspective, whether the process of establishing standards produces the most efficient results for society and whether the level of standardization, or the numbers of standards which exist in society can be considered optimal.

In many ways, standards form the basis for civilization. They are the definitions, or the agreements on definitions which make possible the language, the measurement of time, and the customs. Specific standards for items of production or consumption are developed by many diverse organizations for equally diverse purposes. The United States possesses a significant capacity for developing standards, both public

and private. When set by government agencies, standards promote the general health and safety of the citizens. When set by the military, they provide the basis for technical understanding and efficient acquisition of military hardware and supplies. In the private sector, standards are developed through a complex network of organizations, voluntarily controlled by a federation known as the American National Standards Institute. Today there are over 400 such standards groups operating in ANSI.

Standards, whether established by the government or by one of the voluntary organizations, can favorably or unfavorably affect product cost, performance, and availability. Standards establish, among other things, the obligations of the buyers and sellers in the market. Much is written concerning the many benefits which society receives from standards, yet virtually nothing is written of the costs of these standards beyond the operational costs of standards organizations. The budget for the standards department, the salaries of the engineers and the meeting expenses are the predominant, identified costs. The greater potential disbenefits while not ignored, are not fully evaluated. Only recently has the economics of standardization for society been explored.

In the study of standards it is quite possible to become mired in their history and evolution. The majority of the texts, especially prior to the 1960's, concentrate on the

advances of modern civilization and the relation of specific standards to progress. The most significant elements of standardization are highlighted, such as interchangeability, commonality, or the measurement of time, money, weight, and distance. Although the background of the voluntary standards concept is essential for this study, the reliance on these early accounts gives no hint of the economic implications.

The methodology of this study will involve first, a brief history of standards and a discussion of the various types and functions for which they have evolved. A framework for 'public goods' evaluation will follow with basic cost-benefit model alternatives, economic assumptions, and application or implementation theory. The procedures used by the major voluntary players will then be analyzed to determine the extent to which the theory and practice coincide.

II. BACKGROUND

A. WHY STANDARDIZATION?

1. Definition of the Concept

The basic concept of standardization is a simple one. If left at the level of shoe sizes or light bulb interchangeability, the study of standards seems elementary and hardly worthy of economic analysis. The exposure of everyday life to countless standards developed through history makes this type of study, while simple and intellectually mundane, overwhelming nonetheless.

Exactly what standards are, how they affect producers and consumers, and how they have evolved is not precisely defined. Nearly every author has his own version of the reasons behind standards and their role in society, and most studies of standards begin with the obvious elements of time, numbers, and language. These accounts somewhat reduce, however, the credibility of an economic exploration. After all, attempting to measure the monetary benefit of a common language seems hardly a prudent effort.

Standards are to a large extent merely definitions or agreements. They may be used as a basis of comparison, or they may be accepted for use through authority, custom or general consent. Primarily, standards communicate a message efficiently with least ambiguity. Supposedly, they

represent the best cooperative efforts of affected parties for the common good.

Standards are called 'voluntary', not because they are developed by volunteers, but because they are adopted voluntarily and are not promoted by law. The standards of concern for this study are those created for public consumption by private organizations with private funds and used in industry voluntarily.

While the exact definition of a standard is somewhat illusive, the meaning of standardization is likewise vague. Originally this study was undertaken to investigate the balancing of interests and the weighing of benefits versus costs which were naively believed to be the process. The comprehensive mathematical models, the in depth discussion of effect valuations, and the alternative methods for standards selection were, however, not uncovered.

The literature, regulations, and operating procedures dealt not with the mechanics of selecting the one best size or material, but with convincing others that the standard already developed was supportable. It turned out not to be a scientific endeavor, but a political one. Standardization is essentially a political process. It is pragmatic and it is democratic. The parties which wish to participate cast votes for standards approval and proposals, submitted as standards, are massaged into acceptance.

Because it was approached from an economic, theoretical base, the modern business of voluntary standards development was not anticipated in the planning of the research. The implications of this approval process presented a different framework for determining efficiency and optimality.

2. Origins

The standards creation procedures have not always been as they are today. The reasons behind the evolution of standards and the process of standardization are basic to understanding the industrial revolution. The era of mass production for mass consumption demonstrated that success in business was irrefutably connected with effective standardization. While the motivations supporting different types of standards are diverse, the underlying reason for voluntary industrial standards is profit enhancement. Other types of standards, such as Safety or Health have been affected by government involvement and often public outcry. Nevertheless, the importance of standards has never been universally accepted. The fear of stagnation and the conflict between innovation and standardization have never allowed the process unchallenged development.

During the 1800's, the rising number of industrial and household accidents, particularly boiler explosions, prompted new efforts toward standardization. However, these advances were only a part of a larger movement and stemmed from use as a means to assure interchangeability of

manufactured component assemblies. The prospect of larger scale production, lower costs, wider markets for sale of finished goods and expanded sources for raw materials convinced many of the need for standards and simplification.

The rise of standardization mirrors somewhat the accelerated rate of technological advance. Standards more significantly indicate the need to stabilize technology after a period of vigorous growth. Whether directed at material composition or procedural guidelines, standards reflect the consensus of the interested (involved) parties and the current level of commonly understood technology.

Through standards, one epoch of research is transformed into the building blocks for the next. Standards seem to beget other standards and gain strength from those that proceed. The crawl-walk-run stages of the industrial revolution are also found in the development of industrial standards. The apparent conflict between standardization and innovation is, thus, dispelled.

> Man is by nature an innovator, but he is also a standardizer, and if he were not, he would not long survive. An innovation is successful only when it has become a new standard. (Perry, 1955, pp. 124-125)

While the line between standardization and development is not always clear, standards nevertheless mark the trail and at least indicate a direction of further research needs. Technical advances can be chronicled simply through the International Standards Organization committee's experience:

during the 1950's, transport facilities; the 1960's, environment and human safety; 1970's, new energy sources and fuel supplies; 1976, computers; 1980, data transmission, networking and interfacing of equipments.

Albert W Whitney, the Chairman of Engineering Standards Committee said in the 1920's,

> Standardization relegates the problems that have already been solved to their proper place, namely, to the field of routine, and leaves the creative facilities free for the problems that are still unresolved. (Reck, 1956, p.65)

3. Voluntary Standards

The emergence of the voluntary standards system in the US is curious to the rest of the industrial world. In most countries the government either develops and issues standards which are compulsory, or it leaves the responsibility to private agencies which it may or may not support financially. The US on the other hand, writes some of its own standards, allows private agencies to develop other standards, and promotes some standards in both cases by law. (Melnitsky, 1953, p.81)

Normally, however, standards used in the US are simply documents of convenience, not compulsion. The importance of a specific standard is not whether it was issued by a private concern, an association of private companies, or a national standardizing group. Its value to the society is in its application. The research effort behind the standard, regardless of origin, is key.

In Japan the same type of process for standards acceptance exists, but with greater intensity. Company representatives there meet almost continually in order to map out strategies and to present to the Japanese Government a unified voice. In the US the process is slow, often with company representatives meeting only a few times per year. Hence, the majority of the development work in the US is conducted by each company individually, and only when the technology is widely held do standards emerge. (Deming, 1985, p.52)

The question this raises is precisely the focus of the study. Whether the voluntary standards concept as it now applies, produces the optimal level of standardization in society.

Some have argued that the greatest danger lies not from too many standards as a result of the voluntary system, but rather too few. Others contend that greater government (nonregulatory) involvement is needed. But, most publications about standardization which were reviewed did not address any system wide problems. In any event, systematic economic evaluation of standards development either for an industry or overall for society has to be pursued.

4. Standardization Examples

Most of the historical standards accounts and texts reviewed for this study were written by persons directly

involved in voluntary standards development. The objectivity of the record overall, therefore, is suspect. Appropriate standardization has been credited in these accounts as a major factor in a multitude of human accomplishments. In addition, inappropriate or misuse of standardization has been cited as contributing to some of man's greatest failures. For example, while some have argued that the Allied success in World War II was attributable in part to correct standardization, the Department of Defense has asserted that premature standardization by the Germans significantly restricted their ability to fight effectively. Early in the war, the German government demanded industry-wide standardization, ". . .thereby placing the German manufacturers in such an incongruous position as to virtually compel them to build the aircraft to conform to the size of the standardized bearings." (Melnitsky, 1953, p. 2)

Premature standardization and over-specification are pitfalls in the concept with just as vague a definition as standardization, itself. Criticism of standards in general or of the voluntary system are, thus, often focused on specific inappropriate applications.

In 1974 the Defense Science Board formed a task force to study and evaluate the standards practices of the Department. Dr. J F Shea, chairman of the DSB, admitted the

board approached the subject with a bias against the body of some 40,000 specs and standards. The task force, however, after studying the system, reversed its earlier position and ended supporting the process with relatively minor adjustments. The high costs they earlier associated with standards were found to be the result of misuse and incorrect employment of certain standards. Nevertheless, the Shea report did provide the impetus for the 'tailoring' programs in DOD and did encourage the strengthening of management and control of specifications in general. (Shea, 1979, pp.103-110)

Instances where standards have directly produced noteworthy, monetary results are well illustrated by the military. The cases below involve better selection of competing standards, selection of a set of standards in an environment which theretofore had none, and reduction in the number of insignificant standards. All can be viewed as attempts to standardize correctly.

Annual savings of an estimated $5.7 million are realized by DOD through the selection of an appropriate standard for motor oil. Instead of using three separate grades, depending upon the climate, one standard was applied for all climates. (DSSP, 1986, Case II)

Army tactical shelters inventory, without adequate standards management, consisted in 1974 of over 200 incompatible styles. The Secretary of Defense directed a

study, the result of which was variety reduction to thirteen types. The average per unit cost of a shelter before standardization in 1972 was $40,000. By 1984 the average cost of a standard shelter was $12,300 (in constant 1972 dollars). (DSSP, 1986, Case I)

The Navy was, in the early 1980's, developing a new aircraft training system, the T-45A. The anticipated Full Scale Development cost was over $800 million. In 1984 the Secretary of Defense limited expenditure on the program to $450 million. After an extensive review effort by the program management, the FSD contract was awarded for $438 million. Although there are numerous reasons for the price drop, standards reduction played a large part. A typical military aircraft references over 6,000 specifications. After close scrutiny, the T-45A aircraft references less than 400. (DSSP, 1986, Case IV)

There exists, in the military alone, enough standardization accounts to dramatize the economic value of certain specific standards. These examples do not, however, solve the larger questions of this study and do not lend support to the existing level of standardization in a project, industry or society. Just because a standard that is now in use saves money does not adequately answer the question of whether it is the best standard. Furthermore, it does not necessarily mean that other standards are not

required. Simply listing standardization successes is insufficient evaluation.

B. HISTORY

As was stated, the study of standards can too easily emphasize their history and significant past accomplishments. Nevertheless, they should be at least briefly discussed. Standards have always been used to create order from varying degrees of disorder. The roots of civilization rest, to a large extent, with the creation and adoption of standard practices and objects. The language and the measurement of time were probably the earliest forms. As far back as 2500 BC, the Pharaoh decreed that the Egyptians use a cylindrical royal cubit stone as a standard unit of measure, theretofore undefined. Some of the earliest evidence of standardization for interchangeability of component parts occurred in the 10th Century with the advent of the Chinese moveable type. (ASTM, 1985, p.2)

While new efforts continued throughout the years, it was not until the beginning of the Industrial Revolution that standardization began to accelerate. In the late 1700's the French created the Metric system and proposed its adoption to the British and Americans. Converting the week to ten days and the month to three weeks, the Metric system which originally included such calender reform was spurned for a period after the French Revolution. In fact some of the

French scientists promoting the Metric system were imprisoned or executed. (Perry, 1955, pp. 62-63)

In the US the founding fathers were aware of the issues of standardization and included a statement in the Constitution (Article 1 Section 8) which gave Congress the power to "fix the standards of weights and measures." It is interesting to note that, even in its infancy, the Congress could not agree on the merits of the Metric system and refused to adopt it. Understanding the significance or the importance of standards functions is not, however, synonymous with recognizing the issues. In 1816, in his message to Congress, President Madison said in part,

> Congress will call to mind that no adequate provision has yet been made for the uniformity of weights and measures contemplated by the Constitution. (Burton, 1970, p. 22)

The initial efforts by the Congress toward standardization dealt with another issue addressed in the Constitution which was, not suprisingly, uniform taxation throughout the country.

In 1800 Thomas Jefferson granted Eli Whitney a contract to produce 1000 muskets for the Army. Mr. Whitney in his demonstration of the (mass produced) characteristics of his muskets, dumped a box of parts on the floor of the legistlature and from them produced several identical rifles. Standards historians all note this act as particularly significant and a favorite tale of early success.

The major players in the development of standards were, prior to the 1820's, predominantly politicians or political regimes. Nevertheless, the US government continued to contribute, though not in an authoritarian manner.

Other early standards advances usually followed calamity, while later they were to follow the outbreak of war. The Boston fire of 1869 gave rise to the standard size of a brick, because rapid reconstruction was stifled by building materials' inconsistency. In 1863, Congress, in attempting to untangle railroad problems, reduced from thirty three to one the standard widths of railroad tracks. There are many other such examples.

Most of the remaining historical milestones consist of the creation of the standards organizations and the birth of the voluntary system in the US. In 1898 the American Society of Testing and Materials (ASTM) was established to address concerns in steel, paint, and concrete. In 1901, the National Bureau of Standards replaced the Office of Weights and Measures in the Commerce Department and was directed to assist in the development of National Standards. In 1905, the International Electrotechnical Commission and in 1911 the American Society of Mechanical Engineers were formed. (ASTM, 1985, p.3)

Soon thereafter,organizations and professional societies from virtually every product area began to write standards and procedural guidelines. To accommodate this diversity,

and to better coordinate the standardization efforts, in 1918 the American Engineering Standards Committee was formed by 15 engineers, representing five societies (American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, American Society of Testing and Materials, and the American Institute of Electrical Engineers). (Reck, 1956, p.25)

This represented the first step toward nationalization of voluntary standards. The work of the committee was likened to the first compilation of a dictionary. The AESC was to later become the American Standards Association and much later, the American National Standards Institute. It was the intention of this nationalization effort to be a clearinghouse for independent standards organizations and a source of standards data.

Historically, simplification activities by these organizations and the government have reached peaks during wartime. Variety reduction is almost always the primary method. The most striking examples came during World War I, when government action reduced washing machine types from 445 to 18, cut tire varieties from 287 to 32, and completely eliminated over 5,500 styles of rubber footwear. However, after wartime controls were lifted, variety proliferation resumed. (Hemenway, 1975, pp. 22-23)

In 1920 a more lasting course was set, based upon a survey report entitled, "Waste in Industry", prepared by the American Engineering Council of the Federated American Engineering Societies. The council president, Herbert Hoover, was to become the champion of voluntary standards and the architect of the system as it exists today. In that report it was estimated that more than 30% of the cost of production and distribution of products in the US could be eliminated and that $10 billion could be saved annually through standardization and simplification. (Woolacott, 1985, p.100) Later, as the Secretary of Commerce, Hoover instructed the Federal Bureau of Standards Director, Samuel W Stratton, to take a more active role in the promotion of commercial standards and simplification practices. Stratton objected because of the non-scientific nature of commercial standardization.

> Stratton has good reason to object, for commercial standardization is anything but a research problem. It is loaded with controversies, long range implications, and hazards. As a scientific agency, the Bureau might not be immune to political attack, but a scientist can stand his ground when he has the facts on his side. But commercial standardization opens up economic and social questions to which there can be no iron-clad answers. (Perry, 1955, p.133)

There exists in this reasoning a decided lack of effort toward systematic, economic analysis of the process. The idea that the level of standardization was measureable and that optimal standards were attainable seemingly does not exist.

The cooperative government-industry effort to tackle waste was later dubbed, "The Crusade for Standardization" and Hoover was to continue for decades as its leader. In 1951, in an awards acceptance speech before the ASA, Hoover said in part,

> Standards are the base of all mass production. They make possible more continuous employment. . . . They have sharpened competition. They have cheapened the cost of production. . . . Thus, they have been a factor in our rising living standards. They have enabled thousands of different articles to be placed within the reach of everybody. They do not impose uniformity on the individual, because they make available to him an infinite variety of additions to his living. (Wollacott, 1985, p.100)

The foundation for voluntary standards development is, thus well established. The noteworthy elements of the system are the large number of diverse organizations, working somewhat independently and the lack of central government control. This environment is unique to the US and is neither modeled nor well understood abroad. While there has been little mandatory standardization by direct legislation, federal control in some important fields has been delegated to regulatory agencies which issue standards of many kinds, (ICC, FDA, etc). This is entirely a different concern and will not be further discussed.

C. LEVELS OF STANDARDIZATION

In keeping with the premise that standardization is not rigidly defined nor universally appreciated, the types of standards, the roles they fulfill and the level of

standardization are all imprecise. Generally, past standardization accounts have attempted to divide the concept into concise categories and yet most have divided it differently. Probably the important lesson is reaffirmation of the non-scientific nature of the process.

Standards can be developed on a number of levels. They can be tailored for varying portions of the (user) public, or they can be restricted to a specific group or firm. The difference between those standards written for a small group and those offered for general consumption is the degree of consensus that went not into the standards original development, but rather into its approval. On a most elementary scale, a standard could fill one of four basic levels; company, industry, national or government and full consensus.

Through this reasoning, the most technically sound and credible standards should be those at the full consensus level. Those standards would have passed the more rigorous tests and would have satisfied the more diversified audience. The underlying assumption to this division is that as the standards move up the ladder of approval, it is accepted by successively larger, more influential groups. That is, that the company is always less influential than the industry, industry is always less influencial than the government, and so on. This assumption is not always valid.

The industry, composed of numerous companies may not always outweigh the influence of one of its largest members.

Another scheme for dividing standardization into levels also differentiates them by degrees of consensus. In this concept, a standard can be (1) a company standard, (2) a de facto accepted standard, (3) a major voluntary organization approved standard, or (4) an approved American National Standard.

While a company standard is not offered for outside approval or use, a de facto standard exists with a high enough degree of consensus for wide acceptance without formal alternative standards investigation. Often this type of standard comes from an organization or small group, disproportionally powerful in the market. They may also be short-term solutions and results of ad hoc committees of those groups. They are, nevertheless, not subjected for one reason or another to general discussion and debate.

Standards which have major organization approval have often been developed through procedures less stringent than full consensus. The most demanding test of consensus rests with the American National Standards. With these standards, the developers have demonstrated exposure, focus and consensus of the highest degree. These standards have been designated as the highest priority with the greatest need and use. There were an estimated 20,000 standards of sufficient quality developed by 1978, but only about 9,300

were nationally approved. In most cases national consensus was not attempted nor proven. (NSPAC, 1978, p.13)

The reasons for some standards attaining higher levels than others is most often a function of economics. The cost for generating national consensus is high, (estimated between $200,000 and $20 million), but the increased value of a standard with demonstrated consensus is also high. (Steiner, 1979, p.5)

D. TYPES OF STANDARDS

Within each level of standardization there exists various types. Again, the lines of division are not rigid, nor universally accepted. Because a standard can be designed for such diverse purposes, understanding the reason behind its writing is the most important step. The American Society of Testing and Materials defines six types of consensus standards; test methods, specifications, practices, terminology, guidance, and classification. (ASTM, 1985, p.4)

Test method standards delineate procedures for identification, measurement, and evaluation of qualities, characteristics or properties of a product or service. A specification sets requirements to be satisfied by a product or service. A standard practice is a definitive procedure for performing an operation that does not produce a test result. Standard terminology defines terms, symbols

and acronyms and creates meaning for the language. A standard guide offers a series of options or instructions but does not give a definite course of action. Finally, a classification is a systematic arrangement of materials, products or services.

From these types more specific ideas have been offered. When dealing with a certain product, a standard can be one of quality or uniformity. Quality grades and rates have been established for many commodities. Characteristics of different types of standards can be combined to provide even more broad notions such as Safety Standards or Codes. Consisting of compilations of design rules, material and product minimum requirements, inspecting, testing, and operating procedures, these codes provide, among other things, life and property protection. Still other standards can be directed at interaction between people and machines, such as a typewriter keyboard or a traffic light.

Again, the reasons behind applying different types and combinations of standards to commodities and services is, to a large extent, economic. Grading, for instance, can help firms lacking in differentiation advantages and generally tend to decrease the value of established reputations and trade names. More dominant firms possessing certain product differentiation advantages, therefore, tend to resist attempts at product or service grading. Major paper

companies and tire manufacturers are key examples. (Hemenway, 1975, p.60)

The most widely recognized distinction among types of standards is between Performance and Design. Performance standards are the criteria for product or service operation and function. Design standards, on the other hand, enable exact reproductions of an item which will result in an identical and interchangeable product. Although the distinction between the two has not been made for very long, it is nevertheless, the most widely cited.

First promoted in 1967 by Dr. J Herbert Holloman, then acting Undersecretary of Commerce, the idea of writing a performance, rather than design standard was intended to widen participation of producers in the market. (Mackay, 1985, p.79) The ingenuity of engineers is believed threatened by strict design specifications. Virtually every user and developer of standards recognizes this.

The US Congress passed in 1980 the Regulatory Flexibility Act and OMB issued in 1982 Circular A-119. Both of these were aimed, at least partially, at the design/performance distinction. The US Navy addresses the issue in the Navy Program Managers Guide.

> The Program Manager must ensure that the functional baseline configuration accurately reflects the needs of the Navy. However, it should be broadly defined, thus allowing the contractor the necessary latitude to use innovative technical and production approaches. (Navy Material Command, 1985, p.4-29)

In addition, the Department of Defense Military Standard and Military Specification Manual states, "Specifications shall describe the item in a manner which will encourage maximum competition. Insofar as practicable, requirements should be in terms of performance." (DMSSO, 1985, p.7)

The reasoning for the distinction for the military can be taken one step further. Design standards developed by the government shift the risk of the end product operational capability almost totally away from the producer. Performance standards, however, leave that risk with the producer and presumedly lower the acquisition cost of the specified items.

Other organizations have yet different reasons for promoting performance over design standards. Robert B Minogue, the former Director of the Office of Nuclear Regulatory Research for the Nuclear Regulatory Commission in 1983 stated:

> We should not issue performance standards if they are structured in such a way that they mandate a particular design approach. In the first place it is not our business to design the plants and activities we regulate. (ASTM Seminar, 1983, p.29)

The Underwriters Laboratory publication, outlining the methods of standards development very clearly states, "UL makes every effort to use performance requirements and to avoid construction requirements that tend to limit design." (UL, 1983, p.10) The potential cost of inappropriate

standardization, through the over use of design specifications, therefore, seems to be widely recognized.

The positive aspects of performance standards are improved flexibility, innovation and competition, potentially lower cost, and lessened likelihood of anti-trust violations. Nevertheless, not all instances are equally suited for performance specification. Again, the reason can be economic. The cost of writing a performance specification can be very low, but its application cost can be very high. A performance criteria may, for instance, be, 'a door must provide security.' It is often difficult to develop a test to determine conformance to such a vague standard. Secondly, a performance standard must often be written in terms of performance to be evaluated through the conduct of specific tests. The performance is not often judged in the actual use environment. Test equipment can be expensive and difficult to construct.

Therefore, at the very least, performance and design specifications should not be viewed as opposites, but rather as complementary methods of standardizing. Further, while the costs of over-specification in design are potentially a factor, the same applies to the costs of evaluating performance.

The division of standards into various levels and types is indicative of the complex nature of the process. None of the concise categories is exclusive, nor are they, as in the

case of performance and design, necessarily opposing. As the layers of standards are added (standards citing other, existing standards), the distinctions between types and levels are even more blurred. The economic implications and motivations can, however, be more easily viewed through categorization efforts.

E. ROLE OF STANDARDIZATION

Although the process is political, the role of standardization in an industrial society or the reason for its exercise is essentially economic. The economic pressure comes from several directions. In his illustration of the chief advantages of standards, H W Robb, the former company standards manager for General Electric, said in 1956:

> They (standards) serve to notch up, consolidate, communicate, compare and measure our progress. They are a means to simplify practice, to coordinate and conserve effort, and to help utilize more efficiently our knowledge and resources to the best advantage. They liberalize man hours that otherwise are engaged in constantly reinventing the wheel. To us in industry they are essential to increase economy, and productivity, to cover costs and hence provide more goods and services. . . . (Reck, 1956, p. 295)

1. Management

Standardization can be considered a management function designed to coordinate individual decisions with the objective of optimizing diversity in the industry or firm. This is a diversity of materials and practices. The language of management is money and from that follows

standardization efforts. This realization for managers as well as analysts of the concept is essential.

While most attention is paid to materialistic aspects, such as part dimensions, or test methods, over 50 years ago L.P. Alford stressed a wider recognition of the concept in terms of scientific management. As Frank and Lillian Gilbreth had earlier expressed, scientific management was a search for 'the one best way'. Alford began his analysis by stating four laws:

(1) **LAW OF SPECIALIZATION**
Subdividing work so that one or very few operations can be assigned to a worker improves the quality and increases the quantity of output.

(2) **LAW OF DIVISION OF EFFORT**
Assigning to each worker one or a very few operations that he is better adapted to perform improves quality and increases the quantity of output.

- **COROLLARY**
As the scope of a manager's responsibility is narrowed, his efficiency is improved.

(3) **LAW OF TRANSFER OF SKILL**
The attention and skill required to use a tool or operate a machine is inverse to the skill transferred to the mechanism.

(4) **LAW OF SIMPLIFICATION**
Concentrating upon the manufacture of a single product tends to improve the quality and lower the production costs.

Standards, by this reasoning are criterion of management, as well as quality, performance, or practice. All are used as a basis of comparison. Fundamental to this role is the relation of standards to control; budgetary, production, quality, etc. In fact, management is often

evaluated by its ability to govern, direct, regulate or simply control or adhere to a standard. (Wollacott, 1985, pp. 101-102)

2. Variety Reduction

Variety reduction is often cited as the single most important function of standards. In fact, an estimated 80%-90% of all government standards were developed for that purpose through two separate avenues; reduction in varieties of goods and practices in existence, and restrictions on variety growth. (DSSP, 1986, p.A-1)

Reduced numbers of items of production allow for longer production runs and lessened inventory demands. From these advantages, other benefits flow. Lower production set up costs and operation farther down the production 'learning curve' are good examples. More specific analysis of the benefits will follow in Chapter III.

In restricting further variety growth, the US Navy in the Program Managers Guide states;

> The Program Manager should make maximum use of existing Navy standard hardware and software. Use of standard materials and procedures lead to life cycle cost benefits, higher reliability and established logistic support base, simplified training, proper documentation. (Navy Material Command, 1985, p.4-79)

3. Product Quality

Beyond variety reduction, other functions of standards are emerging. Improved quality control and product safety are the focus of these efforts. Quality

standards exert two positive influences. First they tend to better specify the characteristics of products and allow more accurate comparisons of quality in the marketplace. Second, quality standards may serve to improve the quality or performance by better specification of test procedures.

With respect to the comparative shopping attributes of quality standards for the individual firm, customer pressure is becoming a dominant motivator for standardization. Compatibility and Interface are the new buzz-words of marketing strategy significance. Customers, including the US Government as perhaps the largest customer, are increasingly demanding voluntary standards utilization because of its effect on efficient consumption. Buyers are demanding greater knowledge of ingredients and performance, as measured in terms of standards.

In analysis of a competitive economic environment, several assumptions are usually made. Homogeneous products and perfect consumer information are two of those assumptions directly tied to efforts of standardization. The greater the degree of standardization across products, the better informed consumers will be and the more easily attributes of these products can be compared. Quality standards fill this role.

An excellent example of the importance of standards and the effect they may exert in the market through improved quality can be viewed through the US semi-conductor industry

experience in the early 1980's. The other significant aspect of the example is the dramatization of the problems which may arise if standards are not updated and reviewed.

In 1979 the US semiconductor industry was becoming alarmed by the rapid rise of Japanese competition. The US companies were at that time relying upon quality standards techniques which were almost twenty years old. A study in 1979 by Hewlett Packard found that Japanese 16k DRAMS were 10 times less likely to fail than semi-conductors made in the US. This spurred extensive quality standards review. By 1980 the imported items were 6 times less likely to fail and by 1982 the two were equal. (Semiconductor Industry Association, 1985, p.21)

There are substitutes for quality standards which may differentiate the products in their absence. These are brand name and price. While they may well represent the predominant factors of consumption or selection of items in the market, not all agree to their value or efficiency as Arthur Kallet, Director of the Consumer Union, states;

> Perhaps someday a market place more rational than today's will permit the consumer to rely on those widely offered substitutes for quality standards: Brand Name and Price. If the work of the consumer goods testing agencies has proven anything, however, it is that in the present market neither of these substitutes is a reliable one. (Reck, 1956, p.275)

4. Safety

Closely related to product quality is the role of promoting product user welfare. Although improved product safety has been the purpose behind a few standardization efforts since the boiler explosions of the 1800's, it was not until the 1960's that consumer product safety really began to gain momentum. The increasing threat of government action to regulate and require safety was perceived by producers and was, to an extent, thwarted through the use of voluntary standards. Government, in response, accepted many such standards and made them mandatory.

Some organizations, such as Underwriters Laboratories, were formed by private companies to specifically address safety (in this case by the Electric and Insurance industries). Again, economic necessity brought the change. Today, UL with a staff of over 3100 is the largest not-for-profit safety oriented organization in the world. In other cases, agencies of the Federal Government were established to define safety in products and practices and to develop standards which promote it. George P Larrick, former Commissioner of the Food and Drug Administration:

> In a large sense, the Federal Food, Drug and Cosmetic Act in its entirety is a standard--a broad outline of the high responsibility that must be assumed by those who handle commodities the wholesomeness and integrity of which are essential to public welfare. (Reck, 1956, p.174)

Safety standards as products of a voluntary system are indicative of development of standards in general and well

illustrate the economic trade-offs. Accidents from the use of products or services are not limited to chance failure. Rather they are the outcomes of conscious quality and design decisions. Arthur Johnson, former Chairman of the Standards Council for the American Standards Association, expresses the cost/benefit analysis: "Where the one best way reduces the risk, but increases the cost out of all proportion, something less than the best way can be agreed upon as a compromise." (Reck, 1956, p.149)

Jack Bono, President of Underwriters Laboratories expands: "Reasonable is a term that is applied. . . . It means that our staff appreciates the balance between safety and function, safety and practicality and safety and economics." (UL 1984 Annual Report, p.3)

F. INFLUENCES ON THE PROCESS

Some of the major influences on the voluntary standardization system which are currently affecting its performance and directed efforts are increased consumer awareness, increased foreign competition, more advanced technologies and expanded government reliance. Although overall consumer awareness has significantly increased in the past decade and has caused firms to better standardize, the other factors in the world economy have had an equal if not greater influence. The dominance once held by the US in terms of manufacturing volume has long since

evaporated. Today approximately 70% of all goods produced in the US have a foreign competitor. (ASTM Seminar, 1983, p.24) At the same time world wide standardization efforts have widened. The ever increasing technical complexity of end products is also causing heightened use of standards. Raw materials, component parts and subsystems are all subject to much more refined definition in advanced technologies than in the past. In brief, the demands placed upon the voluntary system are growing, as the pressure from foreign competitors are making success more tenuous and failure more costly.

In addition, the government has come to rely on the voluntary standards to such a great extent that the dividing line between law and volunteerism is blurred. In 1964 a standard developed by the ASTM was the subject of an asbestos-cement price fixing suit, but received the following support from the Federal District Court of Pennsylvania:

> Because of the heavy reliance of the Federal, State and Municipal governments upon ASTM for specifications, the Society may be regarded as an essential arm or branch of the government. (Hemenway, 1975, pp.10-11)

In a more general sense, the major impetus for standardization almost always comes from buyers and is more likely to be opposed by sellers. Because standardization is a political process, the more interests which are involved in the deliberations and debate, the less likely is the

collective efforts' culmination in a useable output. As the number of participants, either buyers or sellers, increases the likelihood of effective voluntary standardization diminishes. That is, if the market for a particular product has few buyers, there is a high probability that standards for that product will eventually be set. If, on the other hand, there are very large numbers of buyers, the probability is low. The result is that almost all voluntary standards in the US exercise control over producers' rather than consumers' goods. The absence of voluntary standards for final goods is largely due to the difficulty in organizing consumer interest. (Hemenway, 1975, p. 18)

In a typical industry where there are few manufacturing firms, many suppliers of raw materials, and many customers for the finished product, the few manufacturing firms may provide inconsistent, though entirely rational, support for standardization. As buyers of raw materials, the few firms are likely to organize and collectively impose standardization upon the many suppliers who will resist. However, at the same time those few firms are likely to oppose standardization pressures from customers. Those firms presenting products to the market may find lessened competitive advantages and decreased managerial perogatives with the existence of standards.

In a market of few sellers, standards can be used in an opposite approach. Establishment of standards in such instances can restrict entry of other sellers to the market. These few firms can then exert disproportional influence and make agreements on price/quantity structures that yield high industry profits.

There are other reasons for some firms' reluctance to effectively standardize. One of the major constraints of standards has been and continues to be upper level management's understanding of its role and significance. The misconceptions here can be in both directions: lack of valued appreciation or over confidence in a standard's ability and business worthiness. Fear that standards denote regimentation, curtailment of materials construction, and limitation of design and imagination has further limited the growth of standards, especially consumer goods standards.

Nevertheless, despite the negative influences, the role of standards in the modern economy remains an important one. Appropriate standardization is a positive force in management, product variety control, quality and safety. With its changing complexion, the world economy tends to rely more on standards today than the economic structures of the past. Increased consumer awareness is advancing standards acceptance beyond the producer level. Finally, while the importance of effective standardization is not universally viewed, the final test of any standard produced

by the voluntary system remains the degree to which it is accepted and used without external pressures.

G. RECENT EFFORTS

A significant modification to the voluntary standards mechanism occurred in 1982 with the issuance of the OMB Circular A-119. The circular established formal governmental policy concerning voluntary standards by requiring all agencies to (1) rely on voluntary standards whenever feasible and consistent with law, (2) participate in voluntary standards organizations when such is in the public interest, and (3) coordinate participation with standards bodies to make the most effective use of government resources. The policy was directed mainly at those agencies of the federal government which used or created standards for products' acquisition.

The proclamation, though significant as a formal policy statement, was merely recognizing reality. Prior to issuance, over 100 NBS personnel already were participating in ASTM. Over 1400 Federal employees worked on ASTM's technical (standards writing) committees. In fact, seven Federal employees had even been past Presidents of ASTM. (ASTM Seminar, 1983, p.13)

The strength of the voluntary standards organizations has long been realized by government writers. Because of the guidance of A-119, more of the private standards are

being incorporated into the government standards inventory. The number of private standards adopted by government increased from 939 in 1979 to almost 3500 by 1984.* Further, an independent assessment of Defense standardization practices in 1984 found that "DOD makes good use of appropriate standards developed by nongoverment organizations. . . ." (Toth Associates, 1984, p.2-2)

If one assumes that increased government participation in a nonregulatory fashion benefits the voluntary system as well as government standards writers, A-119 is wise. Not one article was uncovered in this research which indicated any dissaproval of the policy statement. Government writers expressed benefits in terms of reduced standards development costs and reduced prices of procured items. Private industry writers stated benefits in terms of greater ease of business conduct with the Federal Government and reduced production cost of articles for military procurement.

The cooperation between government and industry or lack thereof has a profound impact on the ability of the two to trade in the market efficiently. Circular A-119 represents a significant step, according to almost all standards

*Data obtained from an interview with Andrew Certo, Director for Standardization and Commercial Acquisition Policy Division, Defense Material Specifications and Standards Office, Department of Defense, 27 February 1986.

writers, toward promoting a cooperative environment. The government, through A-119, does not promote voluntary standardization by making the created standards mandatory, but it does offer the resources of the government for joint standards development in the public interest.

A major issue facing the voluntary standards establishment which has yet to be adequately addressed is the speed of standards development. The traditional practices of standards organizations, where deliberation on a specific standard can take months, appear outmoded in the era of computer aided design. As was briefly mentioned, the Japanese meet this demand and placate the urgency through constant development efforts. The American National Standards Institute is a very large organization. Thus, they are burdened with similar problems associated with any large, well established organization. They are deliberate, but they are slow. A very certain amount of 'end runs' around the bureaucracy weakens the legitimacy and the national character of the system.

This difficulty for ANSI is compounded with the rapid rate of technological advance. As standards are applied to emerging technologies, the dividing line between standardization and development blurs. While an efficient standards effort at the frontier is essential to achieving standardization optimality, the premature application of

standards is one of the greatest dangers facing the standards developer. If the process of standardizing fails here, it fails for the system. The level of standardization which brings the greatest net benefits to society is not likely to be attained if the foundation of the economy (research and development) lacks efficient standardization.

The organizations within ANSI have, however, addressed a closely related problem. As the complexity of items of production increases the probability of achieving efficient standardization for those items falls. The ability of any organization to write effective standards for any item decreases as the level of sophistication increases. If a system is composed of several subsystems, each composed of several components, made of hundreds of piece parts, the first effort of standardizing had in the past always begun at the bottom. Standards for parts were developed, then components, then subassemblies. The result, however, from this process was incompatible systems. A blueprint for vertically integrating development, beginning at the top, not the bottom, was needed.

Modeling is the term used within ANSI for the process of vertical integration of standards development: Networking systems, then developing subsystems and piece parts to accommodate the broader guidance. Further, a not for profit organization called the Corporation for Open Systems, has recently been established in an effort to better standardize

across computer systems. Computer equipment incompatibility is today one of the largest headaches for the industry. Greater cooperation, possibly brought about by increased government involvement, it is believed would accelerate the industry and would free resources of the companies involved to faster innovate.*

Therefore, the problems of system complexity, interoperability, and rapid technological advance are all closely tied. These are the great challenges facing the system. While the role of government in support of the voluntary system is complicated by these issues, many standards advocates believe that the quality of standards created, and thus the long-term success of the voluntary standards mechanism will be determined by adequate, but well directed government involvement and endorsement.

H. GOVERNMENT PARTICIPATION

As has been stated, US government involvement in the creation of industrial standards has always been minor, and until OMB A-119, ill-defined. While agencies purchasing products have tended to write their own standards when adequate private standards did not exist, in general they

*Data obtained from an interview with Marco Negrete, Director of Corporate Standards for Hewlett-Packard, and a member of the Board of Directors for ANSI, 7 March 1986.

have not extended this practice beyond their own acquisition needs. In 1968, of the over 14,000 industry-wide standards which existed, less than 3% had been written under government auspices. (Hemenway, 1975, p.81)

Nevertheless, concern over the participation or lack thereof in the standardization process has long been voiced. There have been several formal studies conducted to assess the government's performance in this area.

In 1977 the Energy Research and Development Administration commissioned the National Bureau of Standards to prepare a comprehensive standards development plan. The plan was intended to provide assurance that the introduction of new energy technologies would not be hampered by inadequate government involvement.

NBS first examined the system in operation and concluded that voluntary standards bodies:

> . . .are performing this complex task with relative efficiency and expertise. Where criticism has been directed toward them, it is frequently, if not always attributable to the failure of the appropriate federal agencies to provide the necessary technical support and coordination. . . . (Steiner, 1979, p.9)

The standards development plan created and then adopted by NBS was based upon three general principles.

(1) The standards to be developed must play an anticipatory role. In some instances this role involves the use of standards to stimulate development of technology. In other instances it shall direct the course of technical development. In both cases it should facilitate the transfer of technology in the private sector.

(2) Voluntary standards must continue to play the critical role at the heart of the standardization system by achieving consensus on specific standards.

(3) The system of standardization must be as simple as possible. (Steiner, 1979, pp.1-2)

Therefore, while government departments such as DOD did not, until A-119, have a clear standards policy, NBS has pursued a well guided course of assistance and support. In addition to emerging energy technologies, the compatibility of systems issue discussed above provided an important area for NBS to carry out this function. Another study, conducted in 1983, provided further justification for this type of government involvement.

John H Young in the introductory section of his study, Effect of Standards on Inrormation Technology R & D, produces an excellent foundation not only for evaluating present standardization activities, but also for guiding future efforts or funding. Young divides the technology of industry into proprietary and nonproprietary elements. Nonproprietary elements include the general scientific and engineering principles that underlie an industry's technology. While the use of nonproprietary elements does not give any competitive advantage, the market competition does provide the impetus for developing proprietary elements based upon those general principles.

Further, while there may be gaps in the knowledge base needed for this proprietary element development, competing

firms are believed to systematically underinvest in developing the nonproprietary class of information. (Young, 1983, p.15)

> . . .advances in proprietary products and production processes draw on the nonproprietary pool of information. Thus there may be a role for the government to support research in advancing the nonproprietary elements of an industry's technology. (Young, 1983, p.2)

The National Bureau of Standards' Institute for Computer Science and Technology assumed this task of coordination and technical base support. The Corporation for Open Systems, briefly discussed in the preceding section is a private effort, aimed at coordinating the proprietary side of the technology. The potential achievements of such an undertaking are, however, restricted by the encroachment into the competitive arena.

Nevertheless, despite these and other studies (including NSPAC), the continued involvement of NBS in support of this technical base is not guaranteed. Specifically, the proposed budget for ICST for FY1987 was cut in half in an attempt to trim the federal budget deficit. If such funding cuts are carried out, the government's involvement in the voluntary system will diminish even further and place even higher demands on the private organizations such as ANSI and COS.

III. COST-BENEFIT ANALYSIS

While the intention of Chapter II was to present an historical background and to discuss the role of standards in society, this Chapter is intended to illuminate the most obvious non-engineering problems which confront the standards developer. This Chapter is constructed to demonstrate the need for economic analysis and justification on two levels--first, for the firm (micro), and secondly for society (macro). The costs and benefits of a standard must be identified and weighed by the firm or organization which creates it. In addition, and just as significant, the costs and benefits of a standard must be identified and weighed for society. The number and variants of standards which exist in society, or the overall level of standardization, is an important topic, though not widely addressed in either the standards or economic literature.

The premise of the discussion is that the positive and negative effects of a standard can and should be measured and that, through systematic comparison of benefits and costs, optimal standards decisions are possible. The firm will select the standard which produces the greatest monetary return to it. Society will prefer the mix of standards (and non-standards) which produces the greatest social well-being.

While this Chapter is intended to present a framework for such analysis, it is not comprehensive and does not reflect every method of measuring and comparing alternatives. Nevertheless, this Chapter does provide a basis for viewing standards from other than an engineering perspective. It is a preliminary investigation. The final chapter of this study will more specifically describe the operations of several major standards organizations in order that an evaluation of their performance based upon this chapter's suggested analysis is possible.

A. WHY ECONOMIC EVALUATION FOR THE FIRM?

The creation and implementation of standards both requires the use of scarce resources and affects the users' resource allocation. Therefore, an economic evaluation is required for an individual firm, or more specifically for the standards department within that firm. The standards department competes for budget funds against other departments of the organization, and therefore must justify its expenses. Further, within the standards department, the expenditure of funds must not only be effective but efficient.

Some standards can be quite costly to create and use, yet contribute little to the firm financially. Other standards may cost little, yet produce significant savings or substantially promote sales. Identification and

measurement of the effects is therefore of prime importance to the firm.

Given the historical significance of standards as presented in Chapter II, a manager of product development in a firm will undoubtedly demand correct standardization of his new items. But at the same time that manager will not blindly allocate money to standards creation without evidence of the resultant value. Thus, competition within the company for budget dollars will require evaluation of standards' effects, even if that evaluation is crude and non-systematic: The greater the competition, the greater the pressure and the more thorough the study.

The dilemma, faced by the standards manager, is two-fold. First, he must select which standards to develop and second he must determine how to measure a standard's worth. In any project there exists various options of standardization effort. Each costs and produces benefits of varying amounts.

A standards manager must judge which area to standardize on the basis of the advantage it gives him in support of his department's funding before the corporate leadership. A standards manager should, following this reasoning, concentrate on standards which will produce the most noticeable monetary effect in the end product. If a standards manager can successfully demonstrate the value of

his efforts, he should be supported through continued funding.

> Each standard has its day in court. The judge is a hard-bitten executive, hands on corporate purse strings, eyes filled with anything but sympathy, and ears open only to the reply to his question: Why should I spend money on standardization? (Melnitsky, 1953, p.17)

Another management decision for the firm concerns what type or what consensus level standard is best suited for a particular situation. The intended purpose of a standard will determine whether its use will be restricted to the company or offered for consensus generation outside. By far the vast majority of all standards used or developed by a firm will be for internal use only, and very infrequently will standards developed by a firm become industry wide or national standards. Most firms will never produce a national design standard.

Most standards used by a firm will be internally generated and applied operating or test procedures and will have limited applicability outside. Many will be particular to a firm as a management prerogative and will, to a certain extent differentiate the firm and its products.

Development of a product design standard by an individual firm will be the result of company deliberations at various stages of a product's invention and introduction to the market. The business strategy, the architectural design of the product and its market evaluation are all

considerations which affect a standard's application and scope.

A standards manager making these decisions is likely to be an engineer with experience in product design or production. Nevertheless, the financial justification for his efforts may require an expertise outside his own. Specifically, the selection of which standard to pursue may be based upon considerations of end product marketability or logistical supportability.

In 1928 this fact was pointed out by N F Harriman:

> Engineering and technical experts have a proper place in any standardization program, but economic factors should be considered at least equally. (Melnitsky, 1953, p.113)

A standards manager must, therefore make his first decision, which standard to develop, by examination of the likelihood of success times the benefit he believes will accrue from the standards existence. The first portion is engineering and the latter is economic.

If a standards manager cannot justify his efforts in monetary terms, he may face budget cuts or (worse) upper management's loss of confidence. Few business leaders will accept standardization expenses because of their intrinsic value or contribution to the common good. Hard data will likely be required eventually.

A failure, however, to demontrate the fruits of the standards may not be indicative of the actual effect.

Valuation of the benefits, many of which will be realized by persons far removed from the production line, represents the second but probably greatest difficulty faced by the standards advocates. Again the issue of technical competence, particularly in marketing or logistics, may be valid.

Standards groups in and out of profit-seeking organizations have faced this problem for decades. If justification of standards expenditures does not rest, at least in part, on specific monetary savings, the spending body will probably not support it. If the sum allocated to the standards department is relatively insignificant and the company overall is doing well, support may continue. But the demand for standardization (without obvious cost avoidances or increased revenues) is very elastic. If the available money diminishes or the cost of the standards department rises, the level of funded support will fall disproportionately. A standards department which does not adequately justify its existence is likely to be one of the first targets in a company cost cutting maneuver.

A lack of commitment and the suspicion of the value of standards is somewhat of a self-fulfilling prophecy. If a standards body does not substantiate its results, its ability to affect significant further results is cut. Sometimes even when solid cost savings estimates are available, they are disregarded.

In 1980 the Department of Defense established the Joint Services Review Committee to investigate the feasibility of standardizing tactical avionics subsystems. They identified five potential candidates and estimated a cost avoidance of $770 million. They requested $64 million to fund the standardization effort, but they received only $21 million over three years. The GAO report which detailed this situation stated the project was doomed to failure, not because it was infeasible, but because of the lack of top management commitment and the funding instability. Over the last ten years there have been three separate high level DOD studies and three separate GAO studies, all recommending greater participation in standards activities and programs. Yet, no program during that period was implemented and adequately funded. (GAO 10 July 1984 Report to SecDef, pp.3-15)

In 1952 Congress passed the Defense Cataloging and Standardization Act which DOD followed in the creation of the Defense Specification and Standardization Program (DSSP) and the Defense Material Standardization and Specification Board (DMSSB). Neither of these organizations has ever been given high priority in funding or operation. The DMSSB fizzled completely in the late 1970's and failed to even meet again until 1981. While there has been lip service to standards activities, policies and objectives, there has been little enforcement, inadequate funding and insufficient

top level attention to obtain the potential benefits. (GAO Report, 1984, p.1)

While it is not suggested that the DOD standardization experience or emphasis is identical to that of private firms, the examples are, however, indicative of the standards advocate's frustration in proving financial legitimacy. A standards manager for the firm will promote standards application for the most efficient consumption of raw materials, the most efficient manufacturing procedures and the production of goods with the greatest market potential. DOD, on the other hand, will strive for the same ideals of efficient consumption and use of materials in hopes of attaining the greatest output. While the organizations are quite different, the focus of standardization activities, and the burden of proving worthiness in both cases are quite similar.

Over twenty years ago a panel, chaired by Frank La Que reviewed the US National Standards Program for the Department of Commerce. In their report they addressed the difficulty in providing economic justification for standards.

> The National Aerospace Standards Committee responded for the aerospace industry and found itself hard pressed, as did other industry associations to provide specific tangible figures on cost reduction or cost avoidance. (Toth, 1984, p.77)

The report went on to further state that: (1) there exists no method for uniform determination of benefits or

costs of standards and, thus, (2) there exists no sound basis for making intelligent technical, economic or logistic trade-off decisions.

> . . .in the absense of any guidelines or uniform gross measures. . .each individual organization is forced to color its decisions by its limited and often parochial interest and knowledge in the area. This action often results unknowingly in failure to serve the best interests of the individual organization as well as the overall industry of which it is a part. (Toth, 1984, p.77)

Although standards have been positively affecting industry for hundreds of years, economic evaluation methodologies for them were not developed until very recently. Because of this, standards departments have enjoyed inconsistent endorsement and have provided easy targets for funding cuts. Standards may affect a firm's profitibility and they may (if offered externally) affect others' profits. The internal generation and application of standards should be economically evaluated by the firm itself. The external effects should be judged not only by the firm, but also on a more grand scale, the methodology for which will discussed in the next section.

For the individual firm or the standards department within the firm, the major hurdles to be overcome involve first proving that meaningful analysis of standards is possible and second, that the estimates for savings are believable. While the specific areas for cost and benefit identification will be discussed below, the point of this discussion is that a firm should pursue the most efficient

as well as the effective standardization practices. The standards it develops either for internal or external use must be economically evaluated in some systematic manner. If the individual firm does not produce economically optimal standards, it will operate at a potential disadvantage in the marketplace. Only through systematic studies can the firm determine the best course of action and compete effectively.

B. STANDARDS AND THE CONCEPT OF A PUBLIC GOOD

Cost/benefit analysis of standardization should take place, not only on the level of the firm, but also in a much larger sense for society as a whole. While an individual company will attempt justification of its efforts to standardize and measure the effects of the standards it creates, so too should industry or even society overall. Are there too few or too many standards for innovation and growth? Furthermore, economists should determine what affects the level of standardization (or the number of standards) in an industry, and what forces enable or preclude the industry from reaching the optimum level.

None of the articles which were reviewed for this study satisfactorily addressed this issue. Nevertheless, information is available in economic literature which, though not specifically applied to standards could be used as a theoretical foundation. It begins with reference to

voluntary standards as 'public goods'. Next, this reference is supplemented by the idea that the benefits and the costs can be summed for public goods decisions and that optimum decisions are possible.

Economists define a public good such that (1) consumption of the good is nonrival (one person's consumption does not diminish the amount available to another person), or (2) it is infeasible to exclude an individual from consuming the good, once the good is provided.

Peter Steiner further defines a public good as "any publicly induced or provided collective good." Collective goods arise whenever a segment of society collectively wants and is willing to pay for a different selection of goods and services than the market on its own will produce. The public good may be publicly or privately provided. Co-ops, trade unions, car pools are all examples of private groups organizing in response to collective demands. Also there are degrees of publicness of goods. Not all the goods produced by the state are purely public, while some goods produced privately may be purely public.

It is possible to distinguish three types of public goods: (1) Those arising from intrinsic characteristics of specific goods that result in hard to market externalities such as the beauty or ugliness of an office building, (2) Those arising from imperfections in the market mechanism

(rather than in the nature of the goods themselves), and (3) Those arising, not from specific goods but from aspects concerning the quality or nature of the environment. (Haveman and Margolis, 1970, pp.21-26)

Standards, though not consistent with the entire idea, would fall into the second category. Standards emerge from imperfections in the market. Peter O Steiner in his text, The Public Sector and the Public Interest states;

> Efficient markets frequently suppose adequate information, sufficient competition, timely adjustment, and modest transaction costs. The absence of any of these may create motives to replace market determination by market provision or to supplement markets with ancillary public goods. (Haveman and Margolis, 1970, p.29)

This notion of standards as a public good is supported if one evaluates the market in which standards are used. One assumption which most make in studying a competitive market is Perfect Information. That is, perfect information exists among buyers as to the quality and ingredients of the product. But perfect information is more of a myth than a likely description of reality.

For information to be perfect in the market, it would have to be free. Product information would, itself be a public good. This is obviously not how most markets operate. Information collection, processing and dissemination can be very costly. The more complex the product, the more expensive the information.

Therefore, because product information is not a free good and is not automatically available to buyers, devices have arisen to help provide it. Advertising, brand names, guarantees, specifications and standards are all mechanisms designed to provide information. These information sources may not, however, be unbiased and several may be required to present a balanced menu on any particular product. Of these devices to better disseminate information, standards which gain consensus and wide application, forfeit the ability to direct the benefits exclusively back to the firm which created them.

Peter Sassone and William Schaffer in their cost/benefit analysis handbook state that since no one can be excluded from consumption, it would follow that no firm would find it profitable to produce these goods. Therefore, they continue, ". . .it is indeed possible to simultaneously observe a demand for some good and an absence of firms willing to supply the good." (Sassone and Schaffer, 1978, p. 90)

A vacuum was thus created for adequate dissemination of information in the market place. Professional associations and trade groups formed to fill the vacuum and supply the public goods. In most countries the government has taken this responsibility. In the US, where government involvement has always been a last resort action upon failure of the private sector, the responsibility has been

more private or shared. Standards in the US, as a result, are generally created by the state only upon failure of the voluntary system to provide them, or upon the states failure to recognize standards which already exist.

C. EFFECT VALUATION

The above discussion is an attempt to make one distinct point: That voluntary standards can be viewed as 'public goods,' even though they are products of non-governmental bodies. With this view of standards as more than engineering articles of design and production which benefit only the firms that create and use them, the next point arises. Standards affect society in a number of ways. Identification and valuation of those effects is the first and most difficult task.

Once the concept of a standard as a public good is accepted, the creation of a standard can be studied on a macro level in the same light as a public policy decision. As with any policy decision, especially public policy, there exists various degrees of attributable results. There are direct, tangible results which usually represent the purpose behind the policy. There may also be direct, intangible results, such as improved customer satisfaction, feelings of nationalism or community, etc. Further, there may be indirect, unintended results (externalities) which may also be tangible or intangible.

The effects both intended and unintended may accrue only to those within an organization, or they may accrue to everyone involuntarily. The effects may benefit an individual, or represent a cost to him. The application of the public goods concept highlights two distinct features of standards. Although the user benefits from the consumption of a public good, others may be positively or negatively affected by the externalities and not compensated. Thus, the important characteristics of standards are (1) the joint products associated with the standard's use, and (2) the absense of markets to capture these effects.

In short, there exists a wide range of possible outcomes to a policy decision. It is generally agreed that the most demanding aspects of Cost/Benefit Analysis, and therefore policy decisionmaking, is the identification and valuation of these effects.

The most complicating characteristic of an effect is the degree to which it may or may not be readily translated to other physical, countable units. If an effect cannot be easily converted to some other measurable unit, it is considered incommensurable.

Some economic theorists believe that truly incommensurable effects of a policy, while not being ignored, should not be the focus of much attention or valuation effort. The elaborate formulas with constraints and factors to accomodate various situations result in

valuations that are too subjective and controversial for scientific use. For these writers concentration on the tangible benefits with conservative, responsible valuation methods will earn the analysis credibility and acceptance.

Other economists take the opposite approach. To them there are no truly incommensurable effects. "Every outcome has a social cost and hence, a shadow price." (Sassone and Schaffer, 1978, pp.34-35) Shadow prices are "taken to be any tenuously reasonable ascription of value to a good not traded in the market." (Thompson, 1983, p.40) An example would be measuring the fear of crime by the amount spent on crime prevention devices. However, the market prices paid may prove to be an inconsistent meter, because of the individual's ability, not willingness to pay.

Somewhat of a middle course in dealing with incommensurables is to include them in a non-quantitative manner. Listing the effects and making note of their importance, without applying valuation formulas, is a more easily defensible method of analysis.

Therefore, an analyst can either attempt valuation of difficult to measure effects, or he may simply value the effects he can readily translate. Once he has determined the relative costs and benefits for the decision options, he can proceed to select the best option.

Whether performed in a conscious, systematic manner, or informally, there must in each case be a weighing of

alternatives and a measuring of effects along a common scale. Industrial standardization will inevitably be measured in terms of money. While the value of a standard to a firm may be determined in a number of ways, the value to the industry should be a summation of the individual interests. Therefore, some guidelines for valuation should emerge if the industry is to select the most valuable set of standards. None of the texts, including the major standards organization operating manuals mentioned a set of guidelines employed by an industry to value the effects of a standard.

D. THE COSTS AND BENEFITS OF STANDARDIZATION

Although Robert B Toth in his book, The Economics of Standardization, outlines a systematic methodology for valuation of the effects of standards, most of the other publications which were reviewed simply list the benefits and costs potentially involved. Furthermore, in addition to the lack of valuation effort, the effects which were specified seem to suggest that most standards writers value in monetary terms the tangible outcomes, and simply list the intangible ones. Therefore, particularly on the cost side, the effects of the standardization process is (costed) valued by the money spent to create them.

Economic theory yields a more broad foundation for identifying the costs of such decisions, but not necessarily a more useful one. There exists three economic concepts

which complicate the valuation problem: market imperfections, hidden costs and opportunity costs. The imperfect markets present the valuation difficulty where the prices paid may not be indicative of the actual value or the actual cost. Since rich firms would generally pay more for the same benefit than poor firms, programs affecting only the rich may incorrectly appear more valuable to society. The ability to pay, not the willingness or desire may bias the measure of specific items and may dramatically understate their value.

In an industry of many different sized firms, but one in which desire for effective standardization is somewhat universal, the expenditures of the largest firms to either create standards internally or through standards organizations does not yield an accurate measure of their worth. The cost of a standard may be misstated if one looks entirely at the expenses of the engineering staff which writes it. Further, a standard should not be viewed as worthless to a particular firm, simply because it did not participate in its creation. The concept of imperfect markets, therefore, does not allow the measure of a standard's worth to be a summation of the costs of its inputs.

The concept of hidden costs are generally associated with the unintended effects or the externalities of a standard. Hidden costs of social policies or public goods

decisions are a topic of tremendous scope by themselves. An important example of one type of hidden cost is outlined by C Bongers in Standardization: Mathematical Methods in Assortment Determination. He calls this cost "adaptation loss" which represents the intangible disbenefit from the acquisition of an (imperfect) standard material or product, instead of a (perfect) tailored material or product.

A simple shoe example will help clarify matters. If a man's feet are between shoe sizes 10 1/2 and 11, he must choose between two incorrect sizes. If he selects a 10 1/2 or an 11, the discomfort he experiences is an adaptation loss. While this is a simple illustration, it nevertheless demonstrates the cost concept.

How such an adaptation loss is valued is not easily determined. Shoes are again a ready example. If the same man could have purchased hand-made, tailored shoes, he would have no size discomfort (adaptation loss), but he would pay more. The difference in price could be viewed as the value of the loss. However, once the example is expanded to more complex products, the loss is more difficult to identify and value.

By taking this idea further, Bongers states that two objectives of standardization are, therefore, the minimization of the total consumer adaptation loss, and

equal distribution of the adaptation loss throughout the standardized items. (Bongers, 1980, pp.23-25)

Consumers, however, do not bear these costs alone. For a firm engaged in manufacturing, this adaptation loss can be illustrated in the standards it creates for the raw materials utilized in production. Standards in this case should define the characteristics of raw materials in order to minizime the costs of irregularities, but without making such inputs unreasonably scarce and thus too expensive.

Opportunity cost is another important aspect of the standardizing process to be considered. The cost of a standard, through this rationale, is not only the amount spent to develop the standard, but also the foregone options which might have been employed with those funds. This is an interesting concept in that standards departments of firms must not only decide which standard to develop among alternatives, but the firm must also decide whether funding for the department is warranted. The other foregone opportunities are, or should be, important considerations if optimizing standards activities exist. When opportunity costs are not considered, inappropriate or overstandardization is a likely result.

The intangible costs of standards are, in most cases, directly related to inappropriate or over specification. Although these costs are hidden, they may often result from failure to adequately assess the best option of standards

expenditures. Thus, failure to minimize the opportunity cost may aggravate the unintended negative outcomes. Unlike the adaptation loss example, most of these costs are difficult to value. Loss of or slowed innovation from inappropriate standards and obsolescence cost from old standards are typically cited.

Theoretically, if a standardizing body is functioning correctly and is thus pursuing the optimal standards, the opportunity and hidden costs are minimized. For the money spent to develop and apply a standard, no alternative exists which will reap equal or greater benefits or cost less for the user public to adopt. Further, because of the many interests involved in a standards organization, the hidden costs or externalities will be anticipated and minimized. The foundation of such an organization in theory should rest upon wide participation from all affected parties (government, consumers, labor, and industry), each attempting to minimize their cost from a standard and maximize their benefit.

Correct standardization would involve zero cost in slowed innovation and correct review would involve zero obsolescence cost. The source of cost which remains is the focus of most costing efforts--the standards organization operating costs.

Figuring the cost of voluntary standards organizations are, like all other aspects of this study, difficult to bound. One reason is because of the close link between product standardization and product development. Another reason is the private, guarded nature of research and development and the public nature of gaining consensus.

Members of voluntary organizations come to meetings with a wealth of knowledge and experience which was not acquired free of charge. Therefore, the cost of the standards achieved from voluntary meetings are not the travel and accommodation expenses. The costs are much greater. One major standards organization studied the problem and concluded that participants annually spend ten times the organization's total budget. (NSPAC, 1978, p.13)

For the individual firm engaged in standards creation the cost definition is much simpler. Most breakdowns of expenses involve fixed and variable costs of (standards) production. The fixed costs include the maintenance of the standards libraries, the membership dues to the voluntary organizations, the training of the standards department staff, the training of the firm's management to use the standardizing process, and the supervision of the standards department.

The variable costs would be directly related to the number of standards developed. These would include expenditures associated with particular standards, the

coordination activities, seminars, and announcements. Variable costs can be further broken down into the more detailed aspects of a standard's creation; development, presentation, implementation, and revision. Development would include preparation, analysis, and research. Presentation would be promotion and publishing costs. Implementation would involve retooling, production and inspection costs.

Determining the operating costs of a standards department in a firm is not difficult, nor is the identification of purely operating expenses for voluntary standards organizations. Nevertheless, these expenses are not the only *costs of standardization*. They are simply the easiest to see. By not attempting to measure the intangible costs or identifying the opportunity costs, an inappropriate standard could be applied and a suboptimal level of standardization could be promoted.

Many of the standards texts have presented extensive lists and discussions of the benefits which accrue from appropriate standardization. The advantages are the focus of much attention. Correctly applied standards do indeed produce substantial advantages in nearly every product field in which the are involved. The National Aerospace Standard 1524 which will be discussed in greater detail below, lists 52 tangible and intangible factors which the industry

considers significant in calculating the standardization savings. While the list of generally accepted benefits of standards is exceptionally long, the most often cited tangible effects include lower costs of design, production, storage, transportation and capital investment. The intangible side is much larger and includes such vague notions as common language, greater user confidence, improved organization integration, and better consumer understanding.

Robert Toth split the tangible benefits into four primary areas: (1) avoiding costs of specifying new items, (2) realizing larger discounts from larger orders, (3) reducing the number of orders, and (4) reducing the inventory and inventory carrying charges. In short, these cost avoidances come from variety reduction--fewer parts to design, produce and store. The economic relationship between a larger volume activity and a lower per unit cost is well documented.

An excellent illustration of these benefits in a specific product line occurs in Appendix C of Government Procurement of Semiconductors, an industry association white paper. In the report, the per unit cost of mass produced transistors in 1985 was estimated at one thousandth of a cent apiece, due predominantly to very high rates of production.

> The semiconductor industry is characterized by increasing returns to scale of production. The increasing returns are due to economies based on experience. . . . Specifically, average cost per unit of output declines as cumulative production increases. More precisely, as cumulative production is increased by a fixed percentage, the cumulative average cost is reduced by a fixed rate. Average costs decline because workers become more familiar with specific production processes and tend to do them more efficiently. At the same time many improvements will be made in the way the production process is organized and performed. (Semiconductor Industry Association, 1985, Appendix C)

In the illustration the economic concept is called the learning curve. This notion was first expressed in the 1930's for airplane production and generalized in theory in the mid 1960's. It is now a widely accepted idea and one commonly expressed by standardization advocates.

The benefits which are associated with the learning curve are most important because they are measurable. In an atmosphere of evaluation where only the (tangible) operating costs of standards activities are included in the negative side, the reduced per unit cost of production (tangible benefit) may provide the only hard comparative data accumulated. Therefore, if justification of standards is based purely on tangible effects, correct and thorough use of learning curve statistics is vital.

Nevertheless, as was mentioned, the majority of effects of standards (and, thus of the benefits) are intangible. Some are quite significant. Examples taken from NAS 1524 include; Improved general communication, Improved user and customer confidence, and Improved mechanization.

While the effects of standards are diverse and often difficult to ascertain, the better the effort to nail down and specifically value them, the better they can be judged against one another.

E. THE CONCEPT OF COST/BENEFIT ANALYSIS

Evaluation of public policy in a systematic manner is an old concept. Sassone and Schaffer define the process as "an estimation and evaluation of net benefits associated with alternatives for achieving defined public goals." (Sassone and Schaffer, 1978, p.3) Cost/benefit analysis is an extension of economics as a social science dealing with behavior. How a man, a firm, or society chooses to employ scarce resources is the essence of CBA.

One of the first formal cost/benefit studies of a public policy occurred in 1667 in London, when Sir William Petty estimated that expenditures to combat the plague would achieve a benefit to cost ratio of 84 to 1. The first publication of the methodology occurred in 1844 with the Frenchman, Jules Dupuit's essay, On the Measurement of the Utility of Public Works.

In the US such studies date from the early 1900's. The first formal study was the result of Congressional interest in public expenditures in the RIVER AND HARBOR ACT of 1902, and later in the FLOOD CONTROL ACT of 1936. Until the

mid-1960's the majority of such studies were conducted by the US Army Corps of Engineers. (Thompson, 1983, p.1)

The FLOOD CONTROL ACT stated that benefits "to whomsoever they may accrue" of federal projects should exceed costs, but no consistent methods were developed to examine or identify the benefits. In 1950 a Congressional Subcommittee on Benefits and Costs of the Federal Interagency River Basin Commission issued Proposed Practices for Economic Analysis of River Basin Projects, but the guidelines were never formally adopted. In 1952 the Bureau of the Budget issued Circular A-47 which became the official, if seldom used guidance.

Later in 1962, Senate Document 97, Policies, Standards, and Procedures in the Formation, Evaluation and Review of Plans for Use and Development of Water and Related Land Resources, became the official policy statement. There exist today various guidelines concerning the performance of CBA in the public sector.

CBA in this context is an application of a field within the broader scope of economics, known as Welfare Economics. The study of welfare economics employs the concepts of 'well-offness' and public policy decisions effects on individuals. In this realm there are four criteria for evaluating economic activity.

Unanimity--Economic State 1 is judged to be social superior to Economic State 2, if each member of society judges 1 superior to 2.

Pareto Superiority--Economic State 1 is judged to be socially superior to Economic State 2, if at least one person judges 1 superior to 2, and no one judges 2 superior to 1.

Majority Rule--Economic State 1 is judged to be superior to Economic State 2, if the majority prefer 1 to 2.

Potential Pareto Superiority--(also known as the Kaldor-Hicks criteria)--Economic State 1 judged to be socially superior to Economic State 2, if those who gain can compensate those who lose so that no one would be worse off in the final state. (Sassone and Schaffer, 1978, pp.6-9)

Other economic concepts which are fundamental to CBA are Externalities, Effect Valuation, Compensating Variations and Consumer Surplus. An Externality or as discussed above, a hidden cost, is an effect of a policy decision which is incidental or unintended, or for which there does not exist a market. Also known as side effects, spill-overs or neighborhood effects, these consequences may be significant and require policy adjustment, or they may never accumulate in importance to affect the decisionmaking process. Effect valuation is the methodology of assigning monetary values to the effects of a policy. Even though the majority of the benefits or costs of a public policy may be intangible, an

effort must be made to value the effects in a systematic manner. The more complete and justifiable the valuation, the better the CBA.

For the beneficiary of a program, a Compensating Variation is the amount of money a person would pay to have a program and be just as well-off as when he had no program and had no payment. For a non-beneficiary, a CV is the amount of money a person would have to be paid so that with a program and the payment, he would be just as well-off as without the program and without the payment. A Potential Pareto Improvement represents a public policy change where the positive effects outweigh the negative ones. If all the positive and negative CV's are added and the total is greater than zero, a Potential Pareto Improvement exists and the policy change should be adopted.

The Consumer Surplus is the amount a user of the policy (or standard) would be willing to pay for a good, or a service less its cost to him. Compensating variation is simply an alternative definition or variant of consumer surplus. Jules Dupuit originated the concept of Consumer Surplus. He asserted that the output of a project multiplied by its price was equal to the minimum social benefit of the project. Some consumers are willing to pay more than the market price and thus enjoy excess utility or

consumer surplus. By definition, this surplus would be a positive CV.

Once standards which are created by voluntary organizations are accepted as public goods, and costs and benefits of these goods' introduction to the market have been systematically valued, the formal process of CBA may begin.

F. COST/BENEFIT ANALYSIS MODELS

Before analysis is undertaken, there are several key aspects of the standardization process which must be recognized. The purpose of the analysis is to ensure the most efficient use of scarce resources, and to identify the region of diminishing returns for a specific effort. Analysis is a tool and not an end in itself. Analysis is most helpful when the economic effects are not obviously trivial, the effects can at least be roughly measured, and the technical arguments and the basic need of the standard are not overwhelming.

The benefits realized often take the form of 'negative money'; cost avoidance, money not spent, materials not handled, time not used. Finally, the effect of a standard can be realized by groups other than production and design and can be valued in a number of ways.

Once the difficulties of effect identification and valuation have been resolved, there emerge several

alternative approaches for evaluation. Maximization of Net Benefits, Minimization of Costs, Benefit/Cost ratios, and Cost Effectiveness are all typically cited models.

In a general sense, performance of any Cost/benefit Analysis follows a rough procedure:

(1) Define the problem

(2) Designate or design the type of analysis to be utilized

(3) Collect the data, measure the effects

(4) Conduct a social impact analysis

(5) Conduct a quantitative analysis

(6) Prepare the results
(Sassone and Schaffer, 1978, p.157)

The social impact analysis considers all the intangible benefits and costs to view any overriding considerations. A.J. Schearer refers to this aspect as the 'Qualitative Approach.' The hard data are reserved for the tangible, measurable effects, while the intangibles are not ignored.

The formal framework for CBA involves comparison of at least two states of society (one with and one without a program). To measure the effects of a program, the following simple theoretical example is offered.

A state is equal to a specific distribution of utilities in a society of N individuals. U_i^j is equal to the jth persons' utility for state i

$S_1 = (U_1^1, U_1^2, \ldots U_1^N)$ and $S_2 = (U_2^1, U_2^2, \ldots U_2^N)$

State 1 is considered better if $S_1 > S_2$

A project is a set of actions (creation of a public good) which will lead society from one state to another. The value of the project would be the difference between the utilities in each state for the individual and the summed differences for society. V is equal to the value of the project to the jth person.

$V_j = U_1^j - U_2^j$

V_j (which is greater than zero) would be the maximum amount as individual would be willing to pay to have a project, (a positive CV).

V_j (which is less than zero) would be the minimum amount an individual would accept as payment to be just as well-off as in the prior state, (a negative CV).

V_j (equal to zero) implies the individual is indifferent to the project's adoption.

Suppose the only effects of the project are an increase in production of Good X (ΔX) and a decrease in production of Good Y (ΔY). Prices P_X, P_Y remain unchanged.

For the individual j, the value of the project is equal to the price of X times the change in X minus the price of Y times the change in Y.

$V_j = P_X \Delta X - P_Y \Delta Y$

The social value for the project (V) is the summation of the positive and negative CV's.

$$V = \sum_{j=1}^{N} V_j$$

$$= P_X \Delta X - P_Y \Delta Y$$

If V is positive, the policy should be adopted. The demands for a policy (a collective good) are in this analysis, complimentary and not competing. The summation of demand greater than zero is a Potential Pareto Improvement--a better state of society. (Sassone and Schaffer, 1978, pp.48-49)

While its applicability to actual situations is limited, this, nevertheless, represents the quantitative specification of the Potential Pareto improvement concept introduced above. The two most blatantly overlooked

elements involved in the procedure are income re-distribution and efficiency. If either of these considerations is overwhelming, CBA should not be used.

By translating the Potential Pareto Improvement concept into a more workable formula, the idea of Net Benefits arises. In actual performance, application of the Net Benefits approach is the simplest. With this method total investment and operating costs of a standards activity are subtracted from the revenues which are generated. The process advocates only programs which, in effect pay for themselves. If two competing programs are compared, the one with the highest Net Benefits is preferred.

Another variation of the analysis is Benefit to Cost Ratio or Return on Investment. The annual revenues which accrue as a result of the policy (standard) are divided by the monetary investment in the effort. The resultant ROI figure can be an excellent gauge of a program, or it can be of little, or no help at all. If two alternative programs (standards) are under consideration, the option with the largest ROI is not necessarily the better. While any candidate policy for adoption should have a ratio exceeding 1:1, the magnitude of the revenues and costs must also be taken into account.

Robert Toth has estimated the ratios for typical medium technology level manufacturing firms at about 7:1, and high tech firms between 10:1 and 20:1. For specific firms he

estimates the standardization ROI for Dupont at 4:1 and for Martin Marietta at 7:1. (Toth, 1984, p.5)

Therefore use of the Net Benefits and ROI methods should follow two guidelines. First, only programs to be considered should have positive Net Benefits and an ROI greater than 1:1. Secondly, for selection of alternatives among mutually exclusive, competing programs, that with the highest Net Benefits is preferred. It is also important to realize that for any one project, several methods of analysis should be used in determining its social value.

For qualitative as well as quantitative analysis, certain rules should be followed in the accumulation of data. The relationships of costs and benefits to the policy (or standard) are not always clear or indisputable. Therefore, the more conservative and supportable the individual cause and effect assumptions, the more widely accepted the data will be. In addition, reasonableness and currency of the data are essential. Common attacks against policy evaluations originate in incorrect assumptions of cause and effect.

When this reasonableness cannot be established and intangible costs and benefits are not numerically considered, Cost Effectiveness is an alternative method of analysis. There are several variations.

In CEA the object is to either maximize the benefits subject to a cost constraint, or to minimize the cost for a

given level of benefits. In these cases it is important for the incommensurables to be displayed and their non-market nature discussed.

CEA is a valuable tool to determine whether an objective is worth achieving, and how alternative objectives might be achieved. Also CEA indexes provide a basis for comparison of alternative proposals. Cost effectiveness indexes can take many forms. For standardization, an index might be the dollar amount spent for standardized parts divided by the total spent of all parts.

Toth expresses CEA of specific standards as summarized in two ways: (1) variety reduction, and (2) the implementation factor. The number of varieties before standardization divided by the number after will provide a reduction ratio useful for comparison. The implementation factor is a measure of the actual utilization of a standard after a reasonable period for implementation versus the expected utilization at the time the standard was developed.

Other authors have used different cost effectiveness ratios, but all are aimed toward evaluation of the money spent and the outcome achieved, a large part of which being incommensurable. CEA is generally less aggressive than CBA, but in certain instances just as valuable. For any project, there may be several ratios to be considered, with no one specific measure the best in all cases.

There exist many other economic tools for evaluating standards activities. Net Present Value is applicable because of the very nature of standardization. Incurring expenses now for anticipated future benefits represents the character of standards creation and is the essense of NPV computations.

$$NPV = B_0 - C_0/(1+d)^0 + B_1 - C_1/(1+d)^1 + \ldots + B_N - C_N/(1+d)^N$$

C_0 = dollar cost of the project in time 0
B_0 = dollar benefit of the project in time 0
d = discount rate
n = life of the project

Cut off period is a concept for either accepting a program, if it will pay for itself in a specified period, or not accepting it. In a rapidly changing technical field this method may be particularly useful. Payback period is a closely related concept which compares projects on the basis of time required to recover costs. While either of these methods may be helpful, both ignore certain important aspects and may be somewhat shortsighted. In any event, the break even point for an activity should be figured if standardization revenue is at all measurable.

If the benefits are not commensurable analysis may be restricted to simple cost minimization. However, without any observance of the benefits, the evaluation is of limited value.

As stated above, the study of the US National Standards Program in 1964 by the La Que panel recommended a systematic

method for evaluating standards be developed. The responses from this study are two-fold. First, the Air Force Institute of Technology created a mathematical model intended for use by engineers when standardizing electronic parts. Although it is a simple mathematical model, it is one which requires a vast amount of difficult to obtain data. The result is that over 50% of the figures are estimates, but nevertheless, it is a workable tool. Cost estimations in such a model must be conservative and readily defensible. (Toth, 1984, p.62)

The other source of analysis was the Aerospace Industries Association which produced document NAS 1524. In this standard nine formulas are given for determining the cost/benefit figures. Twenty pages in length, the document is quite extensive in detailing procedures and even lists 52 tangible and intangible effects of standards.

The purpose of NAS 1524 as stated in the document is to,

> . . .provide uniformity in identification and calculation of the major identifiable cost avoidance and cost reduction savings factors resulting from standardization projects. (Toth, 1984, p.91)

In pursuit of these factors, the nine formulas which were actually simple mathematical models are presented to cover:

- Savings from increased quantity purchases.
- Savings from lessened paperwork and handling.
- Savings from reduced storage requirements.

- Savings from reduced engineering search time (reference documents).
- Savings from using a stocked standard part in lieu of a new design.
- Savings from using a stocked standard part in lieu of a nonstocked part.
- Savings from using a design standard in lieu of detailing the data completely on each drawing.

Each of the formulas, when applied to an incident of standardization will yield a believable dollar savings figure, only if the estimates used as inputs are defensible. Nevertheless, the mathematical models are simple to understand, well thought-out, and flexible.

The fifty two listed tangible and intangible factors of cost savings are extensive and useful when considering most standardization activities. The factors are broken down into broad categories of Engineering, Procurement, Quality Control, Inventory, Production, Maintenance, and General. The procedure for using NAS 1524 would be first, an examination of the proposed standard's effects as aided by the given list of possible factors. The results of this examination should be conservatively converted to dollar figures and applied to the applicable mathematical equations. The resultant values should then be used as a suppliment to the other evidence for creating or applying a standard. The greatest strength of NAS 1524 is that it establishes a way of thinking about cost savings and presents ideas or stimulus for managers to exploit.

NAS 1524 is the most comprehensive methodology for assessing the impact of standards which was uncovered in the study. Although Toth reports that NAS 1524 has been widely circulated and translated to German, French, and Portuquese, the frequency of its application is not known. While it has existed as an analytical tool for over 15 years, few other publications mention it specifically or recommend its use in evaluating standards. Furthermore, whether NAS 1524 or an equivalent is used and informally promoted in standards organizations is also not known. The lack of economic literature and scientific evaluation does not suggest such an informal arrangement exists.

Therefore, from the first three chapters several conclusions can be drawn. First, standards play a significant role in the economic success of industry, yet they are not the focus of extensive economic studies. Second, while the effects of standards appear throughout society, they remain difficult to identify and value. Concepts and methodologies exist, but are preliminary in development and even these are not widely cited in standards literature. Finally there exists in economic literature a basis for developing cost and benefit analysis models specifically for standards which may be utilized in pursuit of optimal choices.

IV. STANDARDIZATION IN ACTION

The final chapter of this study is a summary of the standardization activities of the organizations which are the major contributors to the voluntary system. The organizations chosen for study are SAE, ASTM, and ANSI. Although they represent three of the largest and most influencial groups involved in the standards system, they utilize three distinctly different methodologies for solving or coping with the same economic and social conditions.

A. WHO WRITES STANDARDS?

As was previously stated, the system of standards creation in the US is somewhat unique. The voluntary organizations and the lack of government direction and control produce a complex system where virtually no product or service area is untouched. There are over 400 standards organizations which belong to the federation known as the American National Standards Institute, formed for coordination and standards approval.

While the system may seem cumbersome to outsiders, the absence of comprehensive, centrally directed planning is characteristic of the American Government attitude in general toward the private sector. Mr. Marco Negrete, a member of ANSI's Board of Directors referred to the European efforts as more academic than the pragmatic approach used in

the US. Standards here, are developed primarily where there is sufficient industry interest translated to funding. The adequacy of the voluntary system forestalls government involvement. As Supreme Court Justice Frankfurter once wrote, "Government as a rule undertakes no service or regulation except after private agencies have proven themselves incapable or unwilling." (Reck, 1956, p.34)

According to Dr. E C Crittenden, former Director of the American Standards Association, the process of voluntary standardization in the US works for two general reasons: (1) the desire to maintain a reasonable degree of order in industry, and (2) the desire to keep the freedom of action necessary for progress. (Reck, 1956, p.34)

Benjamin Melnitsky in Profiting From Industrial Standardization, expresses the motivation as self interest.

> Self interest is the dominant factor influencing standards development by all industrial groups. This is as it should be and is completely desirable. . . . (Melnitsky, 1953, p.61)

Since the consumer interest is difficult to organize, the labor interest often lacks the technical expertise, and the government prefers a laissez faire policy, this self interest is most effectively expressed by businesses. (Hemenway, 1975, p.86)

Of the 400 organizations outside the government, the majority produce few standards. The major standards groups produce almost all of the documents and the major companies

which support those groups provide most of their voting members. Therefore, the standards which affect the masses are in effect created by the business elite in pursuit of their own self interest.

David Hemenway well illustrates this aspect of the voluntary standards system.

> Not only are companies well represented, since most engineers are industry employees, but the major firms tend to dominate the standardization meetings. . . . It is clear that compared to the large scale enterprise, a single small firm finds it relatively more costly to pay the expenses of employees engaged in standards activities. While the trade associations could help insure that the interest of the small firm receive adequate representation, the association itself is probably dominated by the major firms. (Hemenway, 1975, p.85)

Hemenway is somewhat critical of the position taken in the standards organizations by the largest private firms and he insists that standards are created in those organizations only when the major firms want them.

> When quality standards are created, we can predict that they will be written at levels that help established, dominant firms maintain their dominance. (Hemenway, 1975, p.90)

In 1978 ANSI formed an independent group, the National Standards Policy Advisory Committee, to study the effectiveness of the voluntary system. NSPAC concluded the following: While over 400 standards organizations have been writing voluntary standards, the procedures of these organizations vary widely. There are 20,000 US voluntary standards which could qualify as National Standards, but only about 9,300 are so approved. And finally, of the tens

of thousands of firms which benefit from standards, less than 1000 are carrying the load financially. (NSPAC, 1978, p.13)

While the above discussion projects a negative picture of the standards process, it raises two, almost contradictory points. The first is Anti-trust. Section 1 of the Sherman Act prohibits combinations or conspiracies which unreasonably restrict trade. An apparent conclusion from the Hemenway criticism is that big firms use their memberships in voluntary organizations to unlawfully or unjustly force smaller firms to drop out of business, or to somehow modify their behavior unwillingly. This judgement, however is not widely shared.

In fact, the contrary is more often cited in standards literature. Small firms benefit from the efforts of the larger firms to a greater extent than they are manipulated or crushed by it. Not one specific instance of a small firm's failure due to a standard was uncovered in this research.

Therefore, to many standards advocates the use of a standard represents its value to the small firms, the industry, and society overall, and wide spread use and acceptance demonstrates high value.

The American Society of Testing and Materials in a seminar to discuss the impact of OMB Circular A119, emphasized that the best assurance that a standard does not

restrain trade is the democratic process within the organization. An organization which ensures participation by the most expert people available, where no one dominates, and everyone is heard will produce standards which promote rather than restrict trade. The major standards organizations go to great lengths to demonstrate fair representation. (ASTM Seminar, 1983, p.34)

The compromises involved in the process of approving a standard are key to the process and are an indication of the objectivity of the outcome, according to Arthur Johnson, former Chairman of the Standards Council for ASA. He asserts that the older a standard is the more likely it is to be founded in objective evidence. Newer standards tend to be more biased, but because of re-evaluation, they become more objective with age. (Reck, 1956, p.150)

Benjamin Melnitsky reinforces this idea, ". . .the degree to which a standard approaches the unattainable goal of complete objectivity largely determines its intrinsic value." (Melnitsky, 1953, p.12)

Thus the framework for the voluntary system is established and the criteria for its performance evaluation is based. Private firms (the majority of which in this case are large and economically powerful), acting to promote their individual interests have formed organizations to create articles which do not unreasonably restrict trade and which preclude government involvement. The deliberations of

the standards groups consist of compromises between the major players and thereby produce 'objective' results. Although this idea runs counter to traditional democratic thinking, David Hemenway was one of the few writers in the study who seriously questioned the practice. Objectivity, it appears, can be achieved through such organizations with limited government interference.

The operation of a voluntary organization is similar in many respects to that of a standards department within a firm. Several of the standards texts listed the most important activities as; monitoring other standardization activities to reduce du licated effort and maintenance of complete standards records, coordinating the activity of experts from various fields, reconciling divergent opinions, pushing correct standardization and fighting over-standardization or economically unsound standards.

The following sections outline the activities of the Society of Automotive Engineers, the American Society of Testing and Materials, and the American National Standards Institute.

B. SAE

One of the oldest and most powerful professional organizations involved in standards development is the Society of Automotive Engineers. First established in 1905 as the Society of Automobile Engineers, in 1917 they merged

with the Society of Aeronautical Engineers. Today they have a membership of over 40,000 professionals from 87 countries.

The priorities of the Society are first, information exchange, publication of its annual handbook and then the development of new standards. SAE is a corporation which in 1984 had total assets of over $22.2 million and had an annual income of $1.6 million. The corporate Board of Directors employes as its agent a Technical Board, below which is a strict hierarchical organization. (SAE 1984 Annual Report)

The Technical Board consists of 24 SAE members and a Board Chairman. Below the Board are first, the standing committees, formed to carry out the operations of SAE, and next, the councils, and then the technical committees. (Appendix A)

The councils are comprised of 7-25 members, appointed by the Board for three year terms. The technical committees are formed by the councils as needed and are the workhorses for the organization. The technical committees develop, review, maintain and repeal technical reports, the output (standards) of the Society. The councils define the scope of the committee activities and appoint a committee chairman. He, in turn nominates other potential committee members. The number of participants may vary, depending upon the specific needs of the committee. The members are approved by the council, subject to disapproval by the

Board. These committee participants need not be SAE members, but the committee taken as a whole must encompass an 'equitable balance of interests.' In addition, one member of each technical committee must be an SAE staff representative who will monitor the committee proceedings and suspend activity if society by-laws are violated.

Under the technical committees, several other groups may exist if needed, such as subcommittees, task forces or ad hoc committees. The organization under a technical committee can be quite extensive. (Appendix B) The principal technical activity and debate takes place in the technical committees or below.

The objectives of the Society, as translated to technical committee activity, are to coordinate and utilize the knowledge and experience of 'parties at interest.'

> The end products of the committee's work are offered as the best judgement of a group technically competent to deal with problems covered and do not represent an industry trade position. . . . Over the years, the extensive use of SAE technical reports clearly indicates that committee members, working as individuals, do produce results that are practical and useful to industry, government and the public. (SAE, 1986, p.91)

The theme of impartiality is strongly emphasized throughout the SAE literature. Balanced membership in the technical committees seems to be the key. The councils are directed to <u>seek</u> interested or affected parties to participate in the committee activities. In addition, and most importantly, members of technical committees are

required to disclose their interest or persuasion. Members are thus classified in order to better evaluate the balance. The committee chairman re-evaluates the membership at least annually to maintain balance.

The output of the committees are technical reports and are published in the Automotive Engineering and/or Aerospace Engineering journals. Every report carries the following statement.

> This report is published by SAE to advance the state of technology and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use. . . is the sole responsibility of the user. (SAE, 1983, Tech Bd Rule 7.7)

Technical reports which are reviewed at least once every five years are primarily written in terms of performance rather than design. Further, "it is desirable that technical reports not contain a reference to sources of supply of parts or products or the identity of the manufacturers." When it is necessary to make such a reference, the phrase "or equivalent" is offerred in conjunction. During the approval process neither the council nor the Board will alter in any way a technical report which has been submitted by a technical committee. (SAE, 1986, p.95)

Just as the balance of membership is designed to ensure objectivity, so to is the voting procedure. In the committees unanimous agreement is pursued. However, where this cannot be achieved, "substantial agreement" must be

reached. Specifically at least three fourths of the voting members of a committee (with at least one half voting) must approve the reports and all dissenting opinions must be aired and resolved. (SAE, 1983, Tech Bd Rule 8)

> Consensus means existence of a substantial agreement. . . and that an objective effort has been made to obtain a mutually satisfactory resolution of all dissenting viewpoints. (SAE, 1986, p.180)

Approved reports are then submitted by the committee to the council along with all unresolved opinions. The council will then strive for full agreement and if not achieved will attempt to resolve disputes. The council can approve (again by a three fourths vote), disapprove, or refer the report to the Technical Board (with unresolved dissenting opinions). Appeals of the process are allowed and are heard by one of the Technical Board's standing committees. A technical report will become a published standard when consensus (three quarters approval) exists in the Board, the council and the committee and appeals have been adequately resolved by the Appeals Panel.

Therefore, the objectivity of the standards are addressed in two important ways. The classification and balance of participants and the voting methodology and "mutual satisfaction" of disputes. The point which was raised by Hemenway concerning the dominance of the major firms in the organizations, however cannot be dispelled with respect to SAE. Appendix C indicates a dominance of large

firms in the SAE Aerospace Council. Nevertheless, such a configuration of membership interest is not on its face suspect nor is it unexpected. Without specific evidence of dysfunctional behavior, especially at the technical committee or subcommittee level, one must assume the Society operates in accordance with its own by-laws and achieves a balanced approach and objective results.

C. ASTM

Soon after the Office of Management and the Budget issued Circular A119 and thereby defined the government's policy concerning the voluntary standards system, the American Society of Testing and Materials conducted a seminar to discuss its implications. The publication which resulted from that seminar, entitled ASTM and the OMB Circular A119, raised many important issues and actually provided much of the stimulus for this study.

According to the then ASTM President W T Cavanaugh, the Circular, although a significant policy statement, "codifies what has been going on at ASTM for over 85 years." The voluntary system in which ASTM is a major player simply represents a management process for the development of consensus standards. For this, large numbers of 'general interest people,' including government employees are required. ASTM is not a professional organization. Much of what Cavanaugh said at the seminar was a counter attack to

the charge of dominance or a justification of ASTM procedures. The supposed large firm domination of the organization appeared to be a point of particular sensitivity. ". . .for a special interest to dominate ASTM is just about impossible." As proof Cavanaugh offered that none of the 30,000 documents issued by ASTM had ever been challenged in court by another private interest.

Cavanaugh did, however recognize the need for this type of scrutiny.

> A standard is an agreed upon way of doing something. The key question that has to be answered is who agreed and under what circumstances? Standards can be dangerous documents...unless the thing is done right there can be many unfortunate outflows. . . . (ASTM Seminar, 1983, pp.9-11)

Unlike SAE in some respects, ASTM is a more broadly based organization, with financial support coming from the sale of its publications and voluntary contributions. Also unlike SAE, the creation of standards is the primary mission of ASTM. Any group is welcome to participate in ASTM and any private group, commercial activity, or government agency can ask ASTM to convene a meeting to cover a specific area.

ASTM is an old, well established organization which provides significant input into the voluntary system. First established in 1898 as the American Section of the International Society of Testing and Materials and four years later reorganized as ASTM, the society today boasts a membership of 29,000, 4,000 of which are foreigners. The

governing body is the Board of Directors whose members are elected by a vote of the entire membership. Appendix D illustrates the basic organization of ASTM.

Under the Board of Directors, the Board Committees consist of Executive, Finance, Society Development, Technical Committee Activities and the Voluntary Standards System Committee. These committees report to the Board but also direct several other subordinate committees and serve as the Society's administrators. The Standings Committees maintain and enforce the Society's by-laws and report to the Board Committees. Potential members of these committees apply for membership and must be approved by the Executive Committee. The technical committees are organized under the direction of the Standing Committees, but then act as semi-autonomous groups. While the scope of their operation must be approved by the Board, and the by-laws they draft must be approved by the COTCO, the technical committees are free to organize subcommittees or task groups below them for standards creation. Appendix E illustrates a typical technical committee organization.

The principles by which the Society operates include:

- Timely and adequate notice of proposed standards development efforts to all materially affected parties.
- Opportunity for all affected parties to participate in the deliberations and develpment of standards.
- Maintenance of accurate records and accumulation of complete data on the development of standards.

- Adequate notice of all proposed actions.
- Distributions of ballots to all those eligible to vote on standards during the approval process.
- Timely reporting of ballot results
- Adequate appeals procedures made available to all interested parties. (ASTM Handbook, 1985, p.1)

ASTM strives to produce quality standards, the integrity of which are based upon consideration and support from a balanced interest group. To ensure this, technical committee members are classified as to their interest as Producers, Users, Consumers or General Interest. The size of a committee is not limited by regulation, nor is the size of its subcommittees. The Executive Committee approves or disapproves applications for membership with an appeals process under the COTCO. The balance of interest in the technical committees is precisely defined so that "the combined number of voting user, consumer and general interest shall equal or exceed the number of voting producer members." (ASTM, 1985, Tech Com Reg 7.5)

The Executive Committee will approve applications for voting membership unless (1) acceptance will create an imbalance on the committee, or (2) the applicant is not technically qualified or knowledgeable in the area of the committee's scope. (Regulation 6.3) If a member changes employers and thus changes his classification, his membership may again come under review by the Executive Committee.

The meetings of technical committees and subcommittees shall be open to visitors whenever standards are being discussed but may be closed otherwise.

Therefore, the objectivity in ASTM is first protected by the balance of interest concept. The voting and approval process is the next instrument to which the Society refers as 'due process.' (Appendix F)

The approval procedures take place on four distinct levels. First the technical subcommittee chairman can initiate and conduct a letter ballot which must be approved by at least a two-thirds majority (with not less than 60% of the eligible voters participating). Negative opinions must be considered and acknowledged by the subcommittee. To consider a negative opinion, the subcommittee can do one of two things. It can convene a meeting to discuss the negative opinion and can then conduct a vote on it. For a negative vote to be 'not persuasive' and thus withdrawn, two-thirds of the voting members must vote 'not persuasive or not related.' If the negative opinion stands, the standard is withdrawn from the approval process to iron out the problems.

The other course of action a technical subcommittee may take is to simply pass the standard with the negative opinions to the technical committee for its deliberation and vote. The committee, after reviewing the standard and the dissenting views can approve a standard only with a nine

tenths affirmative vote (with 60% participating). Negative votes in the committee must again be acknowledged, but only the opinions not previously considered by the subcommittee need to be considered by the committee. Again, the two-thirds vote is required to make a negative vote not persuasive and allow the standard to continue on the approval process. Once the negative votes have been considered and at least two-thirds of the committee believes them to be not persuasive, a standard may be presented (with negative opinions) for a formal vote by the entire Society. (ASTM, 1982, Regulation Section 12)

Letter ballots for the Society are included in the Society's publication Standardization News along with all dissenting opinions which were not withdrawn. Each member of the Society is entitled to one vote. Negative votes from the members of the Society are again acknowledged and negative votes not previously considered are then considered by the committee. Once all negative votes have been rejected by two-thirds of the committee, the standard can be submitted to the Committee on Standards which determines whether due process was followed and consensus was achieved.

Thus, a complicated and obviously time consuming procedure has been developed to ensure objectivity, for each voting stage takes a minimum of thirty days. Appendix G is a summary of the process, the 'Life Cycle of a Standard.' While the procedures designed to balance the membership and

provide a detailed due process, the objectivity of such an organization can still best be judged over time and with respect to its output. Just as the dominance of council members by large firms in SAE does not necessarily lead to a conclusion of biased results, likewise the due process of ASTM does not necessarily lead to a conclusion of objectivity. Nevertheless, the lack of legal complaints over the years tends to support the Society's contention of fair play and objectivity.

D. ANSI

In 1919 engineers from five existing professional societies (ASME, ASTM, AIEE, ASCE, AND AIMME) formed the American Engineering Standards Committee to develop standards on a national level. In 1928 the Committee restructered to allow participation of trade associations, corporations, and government agencies and, thus formed the American Standards Association. ASA remained until the late 1960's as the primary force behind the national standards efforts. Both AESC and ASA played an active role in not only coordinating national standardization efforts of other groups, but also creating standards, themselves.

The original principles by which ASA operated were voluntary use, public interest and judicial methods, consensus, and flexibility. ASA was founded to operate broadly in the public interest and not merely in the

interest of its members. They created standards, the adherence to which was never enforced, but which were based upon the consensus of all 'substantially concerned' parties. Although one of four methods were encouraged, any manner which demonstrated consensus was acceptable.

According to Arthur Johnson, consensus for ASA means--

> . . .that all who are legitimately concerned with a project have the right not only to be heard, but also to be recognized as having competence to contribute their experience and their opinions...which cannot be overruled merely by a majority vote.

Johnson went on to outline the primary concerns of the drafting committees as:

- the relative weight of specific special interest participants,
- the relative experience of those casting negative votes,
- the economic impact of the standards on those casting negative votes,
- the objectivity of the affirmative vote. (Reck, 1956, p.150)

The preferred methods for gaining consensus were Sectional Committees, Existing Standards, General Acceptance or Proprietory. The Sectional Committee method is very similar in operation to the technical committee procedure of ASTM. The Existing Standards method often led to modifications of de facto standards already in use in hopes of more widespread acceptance. General Acceptance was simply a balloting of concerned parties over a standard being developed. Only Unanimously approved standards were

passed. Finally, the Proprietory method was reserved for revisions of existing ASA standards, done by the preeminent firm in the industry. (Melnitsky, 1953, pp.72-73)

From 1966 to 1969 a major reorganization transformed ASA into the American National Standards Institute and significantly changed its operation. ANSI no longer creates standards but simply provides a medium through which other organizations produce national consensus standards. More stringent guidelines were drawn than used in ASA and more precise definitions were made to reduce the subjectivity of operations. Outside organizations which apply for and receive accreditation then use the structure and procedures of ANSI to promote their standard and gain national consensus. (Sullivan, 1983, pp.22-23)

The ANSI Board of Directors employes an Executive Standards Council (ExSC) which delegated specific responsibilities and establishes standards boards and committees. The boards and committees operate within a scope assigned by ExSC and act as the Institute's administrators. The breadth of the organization is quite wide as over 200 committees now exist.

Approval of standards as American National Standards is reserved and delegated by the Board of Directors to a Board of Standards Review. BSR consists of between nine and eighteen members which are selected by the Board chairman and approved by the Board of Directors.

BSR has the responsibility to verify that the due process requirements of ANSI have been met in the development of submitted standards and that consensus has been reached. BSR must be satisfied in these two areas to approve a standard. Other administrative considerations include, but are not limited to, evaluation for possible conflicts with other existing standards, and the affirmation that the standard was submitted by a group in an area for which it was accredited. BSR acts only on this basis. BSR does not judge the technical content of a standard.

While the minimum criteria for due process are specified by ANSI, actual procedures may vary between groups. An organization must, first of all, be open to all directly affected parties.

> There shall be no undue financial barriers to participation. Participation cannot be conditional upon membership in any organization, nor unreasonably restricted on the basis of technical qualification. . . . (ANSI, 1983, Procedure for Development 1.2.1)

The organization must represent a balance of interest within the scope of accreditation where (1) no more than one third of the membership of a committee writing safety standards represents a single interest, and (2) less than one half of the members writing product standards represent a single interest. Fair representation in an organization is assumed unless challenged by an affected party. (ANSI 1983, Procedure for Development 1.2.2)

To more easily determine the balance, members of accredited groups or committees must be classified at least as Producers, Users, or General Interest. More specific classes may be used if needed such as, but not limited to, Consumer, Insurance, Labor, Regulatory Agency, or simply Expert.

In order to provide opportunity for public comment, proposals for new standards are submitted for publication in Standards Action, the Institute's biweekly journal. All inquires or objections which are then expressed must be answered or resolved. Finally, an accurate and complete record must be maintained by the accredited organization of its proceedings, ballot results and dissenting opinions. Thus, due process requirements within an accredited organization are, at a minimum, openness, balance of interests, publication and wide dissemination, and accurate record keeping.

For a standard to be considered for approval by ANSI it must also demonstrate evidence of national consensus. There are three methods all of which are considered to be equivalent. The methods are Accredited Organization, Accredited Standards Committee, or Accredited Canvas.

Using the Accredited Organization method a standards writing group follows its own procedures which were approved by ANSI. Upon successful demonstration of consensus at that level, the organization then submits the standard for ANSI

review. Since both ASTM and SAE are accredited, one can readily discover a degree of flexibility in proving consensus.

Generally to be accredited, an organization must use approved operating procedures, provide for an appeals mechanism, cooperate with ANSI with advice on new efforts and needs, consider applicable international standards, and provide a summary of votes and responses. Applications for accreditation are subject to approval after a 'comment period' and reviewed by the Audit and Accreditation Board. The process takes between three and six months.

Under the Accredited Standards Committee method, a group of interested parties form a committee to address a specific standards area. The participants must be sufficiently diverse to prevent domination and the scope of their operation must be bounded in their application. They may either draft their own operating procedures which must pass ANSI scrutiny, or they may simply adopt a set of ANSI model procedures. While the same principles of due process are to be emphasized, either set of procedures must demonstrate consensus.

Finally, using the Accredited Canvas method, an accredited sponsoring organization develops a proposed standard and a list of affected parties. Then using the ANSI provided canvas technique, the organization polls the affected parties for approval. Again the dominant

characteristics of the methodology are the widest dissemination of information to the affected parties, resolution of dissenting opinions and an appeals mechanism.

Consensus is, thus, determined by BSR to have been demonstrated by one of the three methods when 'substantial agreement' has been reached by the accredited group and a 'concerted effort' has been made to resolve disputes. Actions on standards by BSR require an affirmative vote of not less than two-thirds of the entire Board. All proceedings of the Board concerning a standard will be published in Standards Action in order to again provide opportunity for public comment. (ANSI, 1983, BSR Proc. 5)

Appeals can be made on three levels. First, an appeal should be directed at the accredited organization which developed the standard. Once this has been exhausted, a BSR decision can be appealed directly back to BSR. The same voting rules exist in both cases for the appeals decision. Finally an appeal can be made to the ANSI Board of Appeals. In general, consideration of appeals shall be fair and unbiased, handled expeditiously, with the right of all involved parties not denied and without any undue burdens.

Through these procedures ANSI provides a medium for other voluntary organizations to widen the applicability of their standards and receive national recognition and acceptance. ANSI employs the common principles of balanced

participation, wide, free exchange of information, resolution of dissent and consensus.

In addition to these activities ANSI manages and coordinates US participation with foreign standards groups and is the official US member in the International Standards Organization. As a clearinghouse and information center for American Standards, it maintains effective interface with the government on standards issues by giving advice, counsel, and testimony before Congressional Committees.

In 1978 ANSI formed an ad hoc study group to devise a National Policy on Standards for the US. The specific recommendations of the group called for the organization in the Executive Branch of the Federal Government, a Government Standards Coordinating Center and in the private sector, a Private Sector Coordinating Center. The two agencies would then work together to identify the priority needs of the nation, coordinate the public and private interests involved, and, thus more efficiently create the types and numbers of standards required. ANSI has since modified its operation to act as the Private Sector Coordinating Center, but no Federal Government action has been initiated to create the Government Sector Center.

V. CONCLUSION

The intention of this study was first, to investigate the importance of standards to society, consider standards from an economic perspective, delineate procedures for evaluating their creation, and finally, discuss actual organization regulations and operations. There are several conclusions which can be drawn from the preceding chapters, and yet many others which may not.

A. CONCLUSIONS

(1) The role of standards in industry and society is fundamental. The future demand for correctly developed and applied standards will likely not diminish, but will expand. Furthermore, while the demands imposed upon the standardizing departments within companies and upon the voluntary standards organizations will increase, the appreciation for their work will grow at a much slower pace. Management, not only in private industry, but in government as well, will continue to view internal standards bodies with skepticism and will seldom fully fund, or even adequately fund their efforts. This follows from the treatment standardizing bodies have received throughout history.

(2) Standards which are developed and used only within specific firms, and thus remain private goods, should be

critically evaluated by the firms individually in order that economically sound business decisions can be made. Standards greatly affect the cost of doing business, and thus deserve the same scrutiny in application as other inputs of production.

(3) Standards engineers or departments within firms should attempt to justify their efforts and their expenses by using a systematic method such as NAS 1524. If these justifications are not made, standards funding will be subjected to undeserved restrictions or cuts. These justifications alone, however, do not guarantee funding support.

(4) National consensus standards, as well as other standards which are widely used outside of the firms which create them, can be viewed as public goods and should be assessed in terms of their overall effect on the economy. Furthermore, the positive and negative effects of these standards can be summed and optimal standards decisions can be made in a manner similar to that of other public policies.

(5) The major propellant behind the standardizing efforts appears to be the enthusiasm and dedication of relatively few individuals, (few in terms of the multitude of persons ultimately affected by standards). These people are to a certain extent silently creating the standards upon

which industry and society depend. Although their work is well known within highly specialized circles of engineers and designers, it is virtually unknown to the user public.

(6) The four criteria for evaluating economic activity are Unanimity, Pareto Superiority, Majority Rule, and Potential Pareto Superiority. In this regard the voluntary standards organizations are established in by-laws and regulations in such a way as to arrive at the best economic decisions. Voluntary organizations strive for Unanimity in making decisions, but when such cannot be achieved, they do not simply rely on Majority Rule. Rather the standardizing groups insist upon the mutual satisfaction of disputes and the modification of standards to gain the highest possible consensus. The concept of Potential Pareto Superiority is entirely consistent with the 'balance of interest' and 'due process' characteristics of the groups. The voluntary standards system, if used as it was intended, can produce Potential Pareto Improvements and can create standards which deliver improved benefits to society.

(7) The accusations of dominance of standards organizations are irrelevant for several reasons. First of all, the greatest inhibiter or limit upon the effectiveness of a voluntary standardizing group is not internal power struggles or large firm dominance. It is technical competency. (Negrete interview) As systems become more complex, the pool of eligible or qualified participants

shrinks. Private individuals from whatever size firm are not normally denied access to standards organizations because of their affiliation, but they may be denied voting rights because of their lack of ability to intelligently contribute. The SAE voting requirements are an example.

Organizations which produce national consensus standards follow regulations which are designed to deny dominance by single industry or firm interests. They also provide publication access to knowledgeable contributors and dissenting opinions. Further, standards organizations are not immune to anti-trust prosecution. Small firms can thus voice their opinion, participate in deliberations, vote in most cases, appeal almost every standard decision, and presumably seek damages in court for any legitimate disadvantage.

In final response to the dominance accusation, the question of who best should create standards arises. Most major standards organizations stress that members act as individuals and not as employees of large (or small) firms. If members are in fact not acting to further the interests of their firm, but rather are promoting the public interest, the origin of their membership should not be an issue. If this is not occurring, and members are voting their company line, eventually such action will be exposed. But, if legal contests are not being waged, the system is probably functioning as designed. Furthermore, if members of large

firms are not allowed to participate in their present numbers, who should fill the void? Virtually no one believes that government is well suited to fill this role. While it is easy to criticize the membership, it is difficult to prescribe a better one.

(8) Lastly, in terms of standards as public goods, there does not exist an easily identifiable measure of standardizing performance. While individual standards may be best selected from alternatives to maximize the net benefits to society, the overall effort and achievement of standards groups cannot so readily be judged. If one asks whether SAE is adequately providing the automotive industry with the best possible array of standards, the answer will undoubtedly be formed with, at least some, reference to the Japanese or European auto industries and standardizing activities. Without (or even with) such a comparative element, the evaluation of SAE performance is difficult. In short, there is not an objective or absolute means of performance evaluation for the voluntary system.

B. SHORTCOMINGS OF THE STUDY

(1) Without doubt the greatest failure of this study was to uncover a sufficient quantity of recent data or literature. Beyond the two publications by Robert Toth, the data available were either specialized or old or both.

Studies of standards are suprisingly rare, given the tremendous affect they exert on industrial development.

(2) The review of the standards organizations operating manuals gives an outsider a descriptive formula for gaining consensus and creating national standards which may or may not have anything to do with reality. Just as one cannot read the Constitution and then critique the work of the Senate, the obvious missing element of this study was actual participation or extensive interviews of participants.

(3) At the outset this study was geared toward an evaluation of mathematical models (such as the one presented in Bongers' text) which were believed to dominate the decisionmaking process of creating standards. Whether mathematics has any relevance to developing standards cannot, however, be established. Bongers and Toth mention multi-variable equations, but none of the voluntary standards manuals give any direction beyond political process.

(4) Finally, the analysis made in this study of the standards decisionmaking process to general economic concepts is certainly not a refined one. Studies which may follow may best be directed toward group behavior and social policy setting in theory, and toward the actual compositions, operations and performance of the major voluntary groups specifically.

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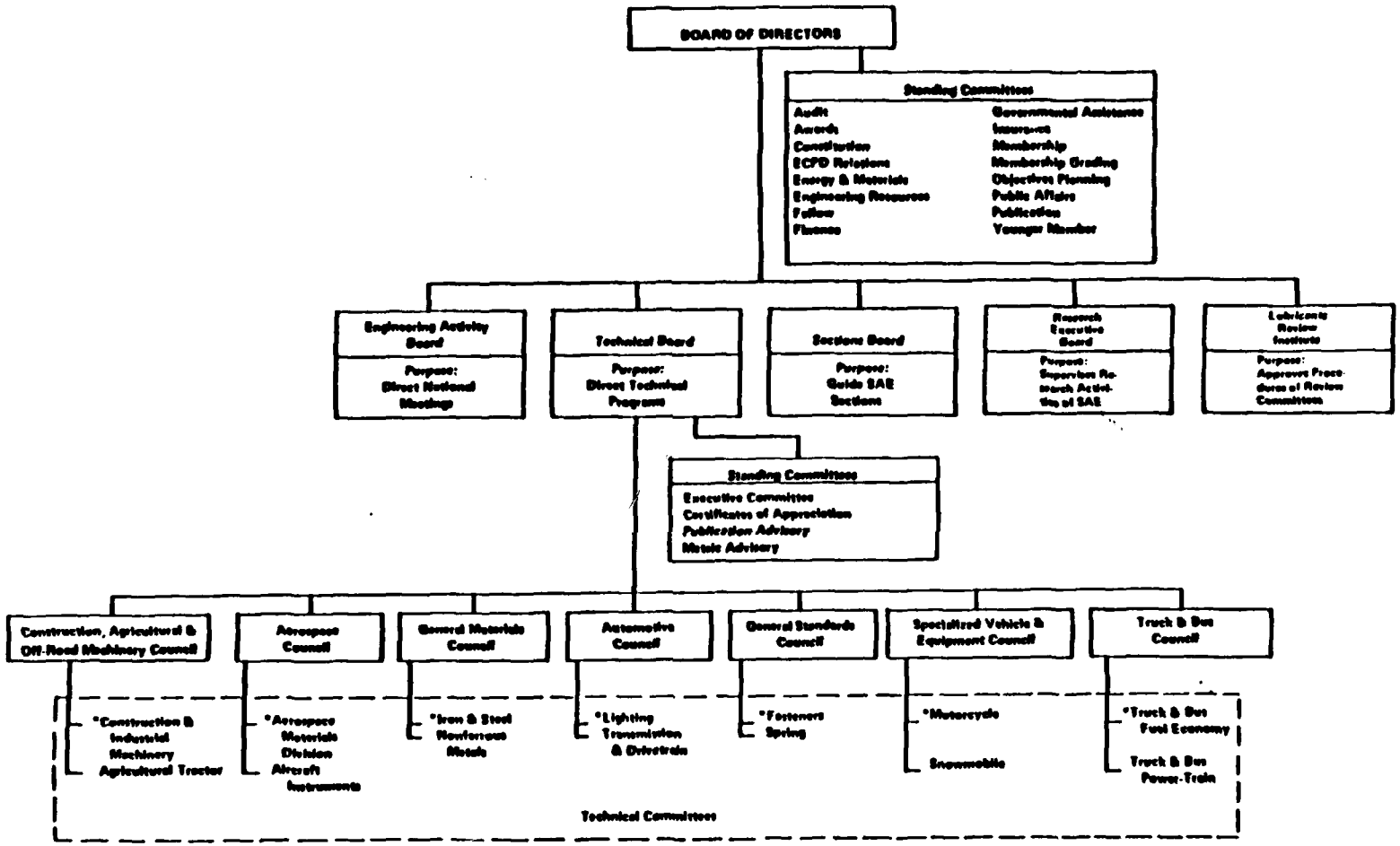

*Only typical examples of committees reporting to the Councils are shown.

FIG. 1—SAE ORGANIZATION

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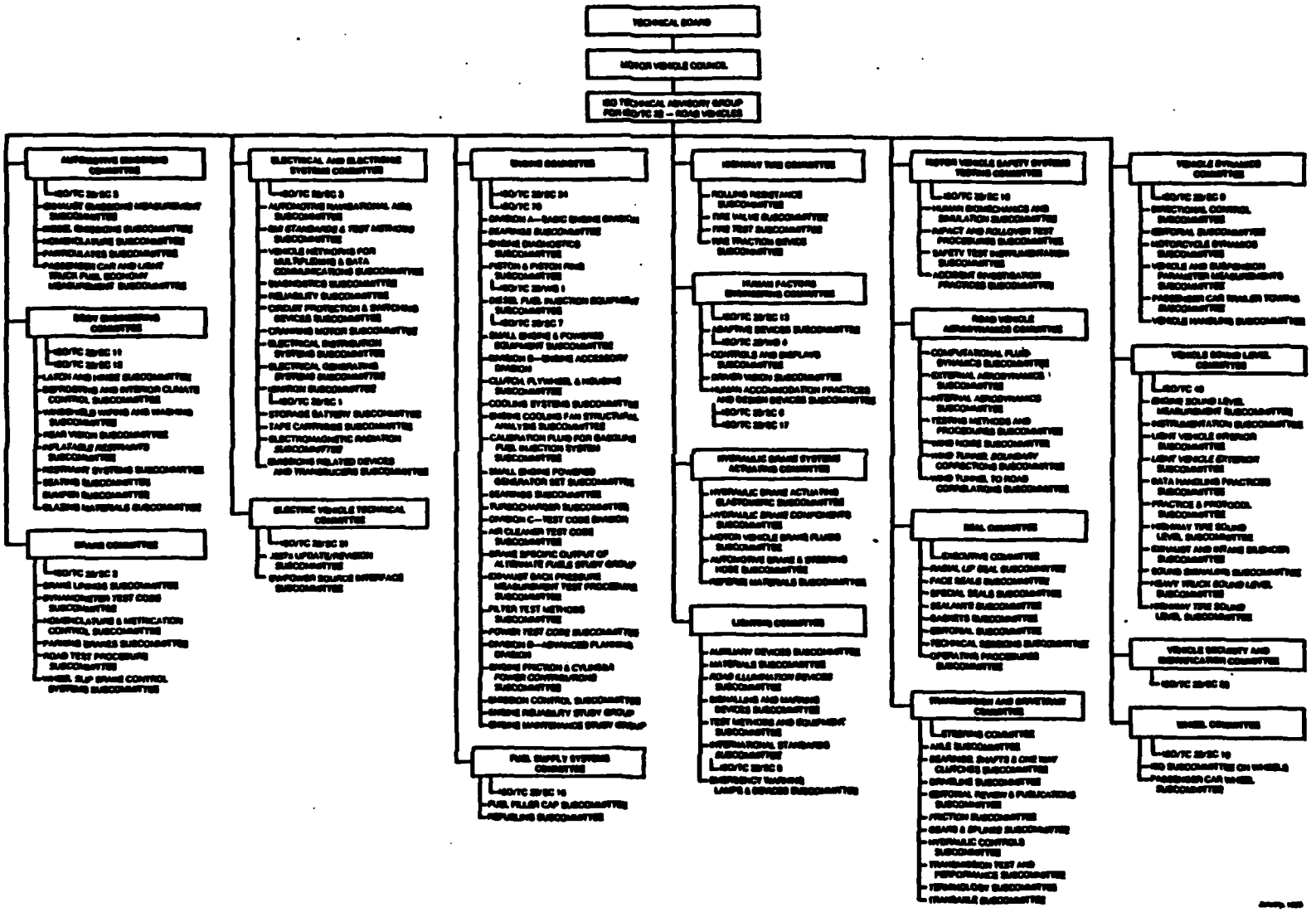
SAE MOTOR VEHICLE COUNCIL ORGANIZATION



SAE AEROSPACE COUNCIL

C. Julian May, Chairman
Delta Airlines

Charles A. Anderson
General Dynamics Corp.

Bruce Aubin
Air Canada

Stephen S. Baits
Sundstrand Corp.

M. Craig Beard
Federal Aviation Administration

David R. Blundell
Rolls-Royce, Ltd.

Bernard D. Brown
British Aerospace, Inc.

Benjamin A. Cosgrove
The Boeing Co.

Thomas F. Donohue
General Electric Co.

Joseph T. Gallagher
Northrop Corp.

Felix Hom
Rohr Industries, Inc.

K. W. Johnson
Trans World Airlines

Ronald D. Neal
Gates Learjet Corp.

Edgar A. Perry
B.F. Goodrich Co.

Bruce E. Peterman
Cessna Aircraft co.

Robert F. Ray
Lockheed-California Co.

Willian Ritchie,II
United Airlines

Roger D. Schaufele
Douglas Aircraft Co.

Edgar Schneider
Pratt-Whitney Div.

Herbert H. Slaughter, Jr.
Sikorsky Aircraft Div.

George P. Townsend, Jr.

Raymond Valeika
Pan American Airlines

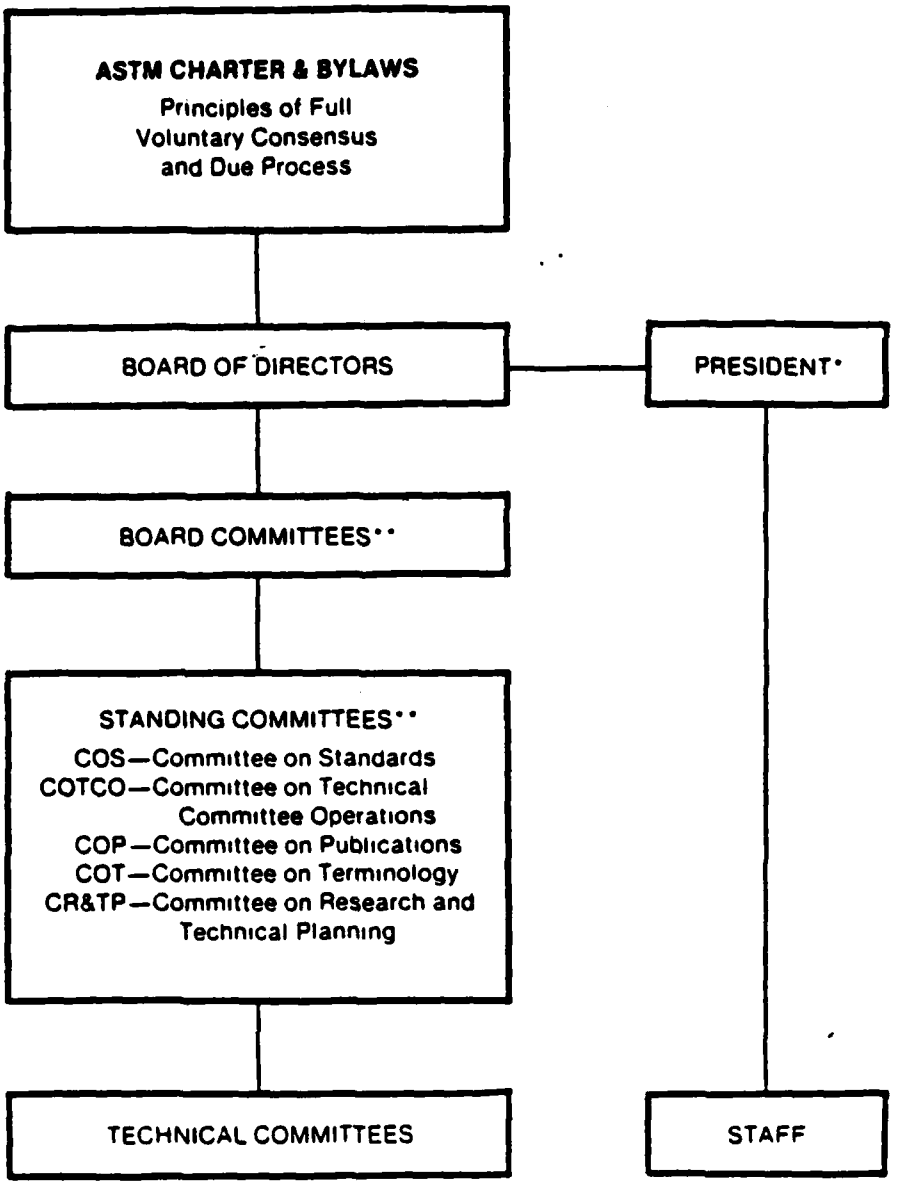
William D. Wise
Beech Aircraft Corp.

Charles Wollmershauser
American Airlines

Harold M. Woody
Flying Tiger Airlines

Samuel P. Miller
Defense Mat. Specs.& Stds.
U.S.Dept. of Defense

APPENDIX C



*The President is a nonvoting member of the Board of Directors.

**For full descriptions of these committees, consult *Regulations Governing ASTM Technical Committees* (appendix).

FIGURE 1 **ASTM Organization**

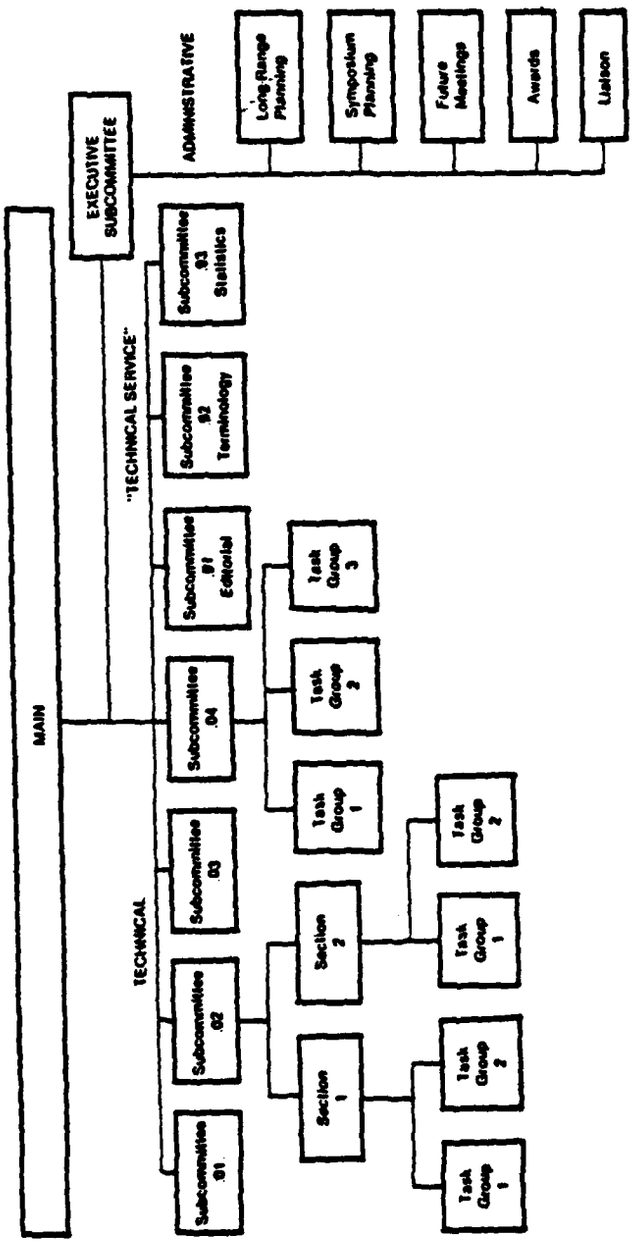
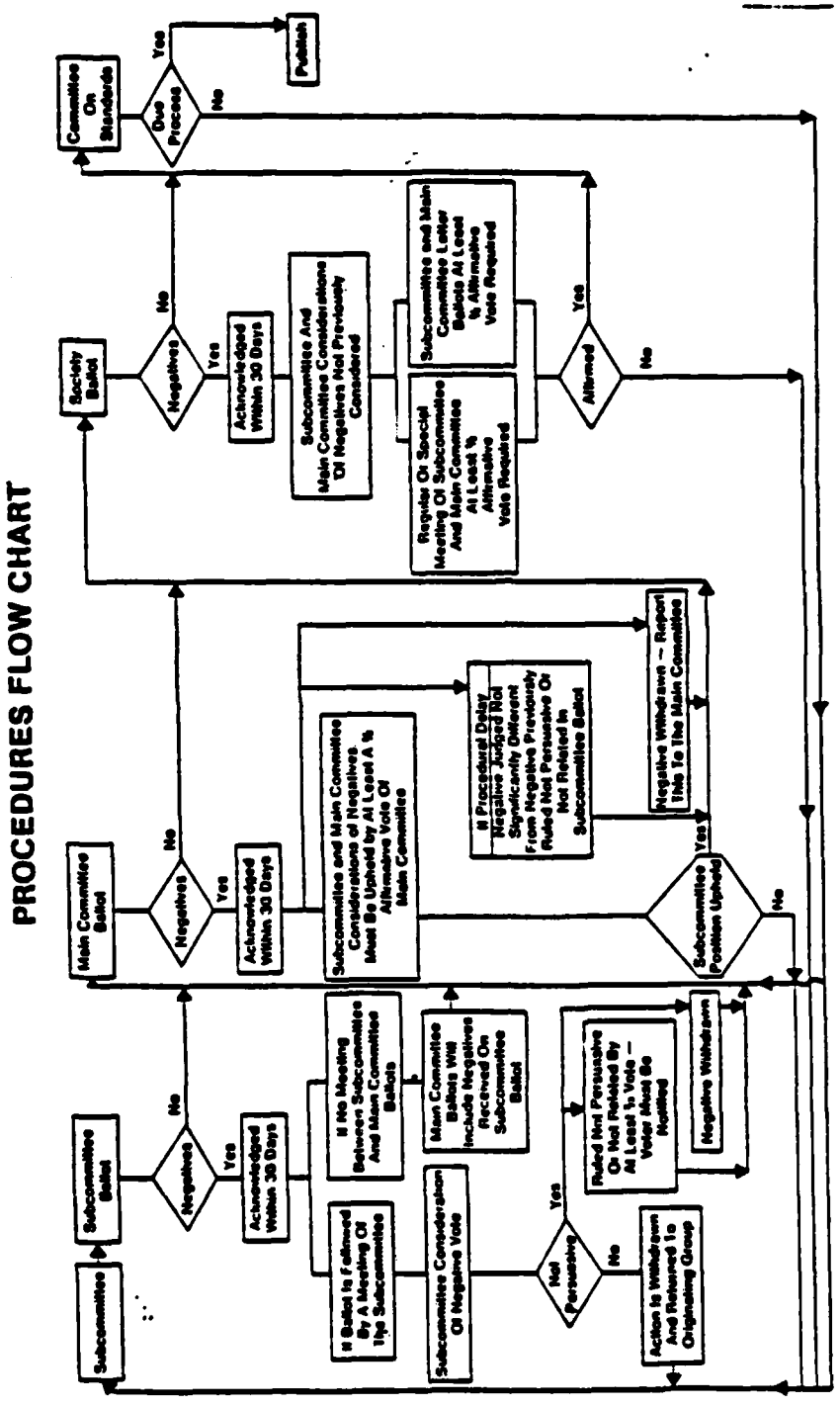
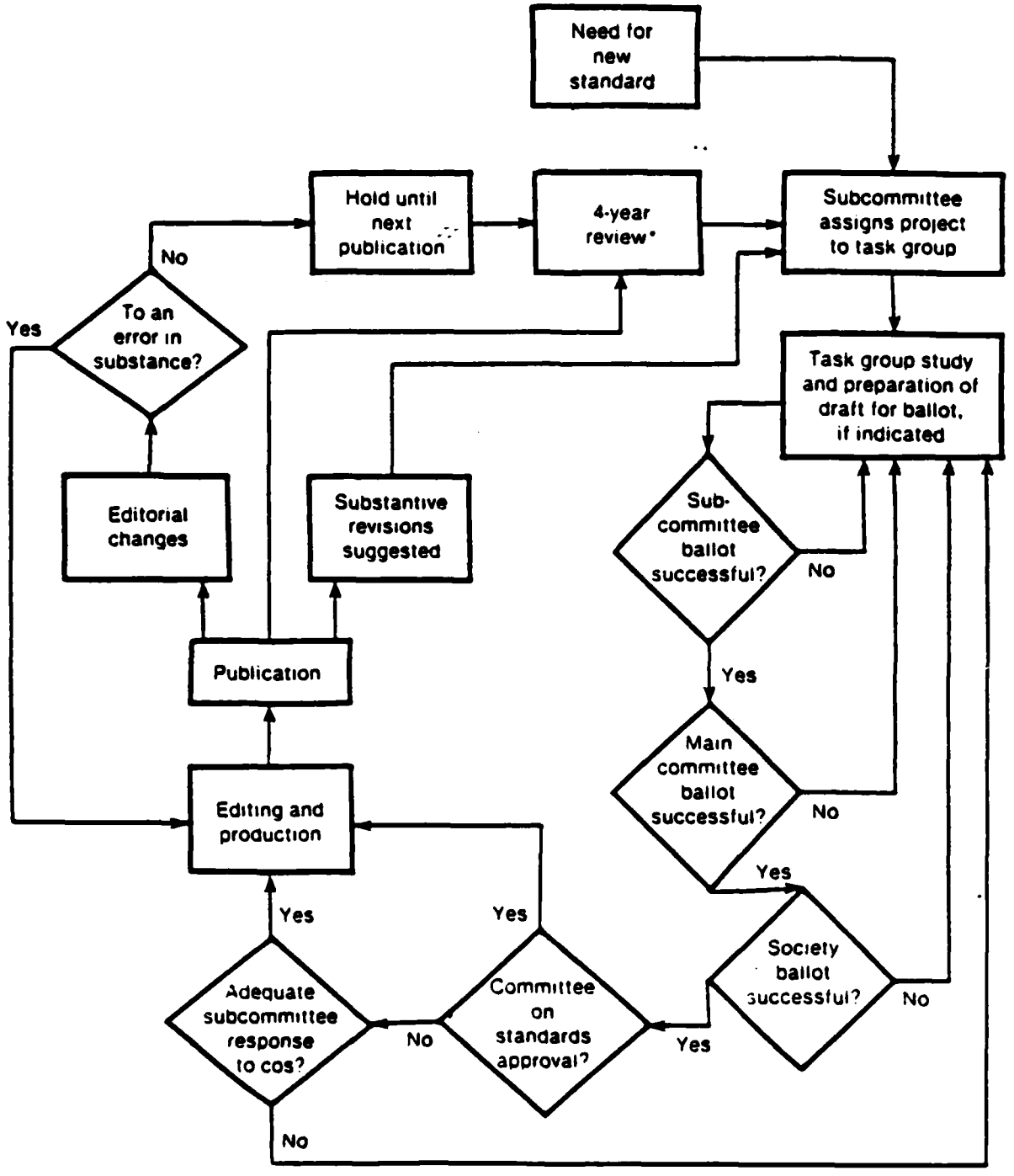


FIGURE 2. Typical Technical Committee Organization

APPENDIX E


PROCEDURES FLOW CHART
Committee On Standards
Due Process
Yes
No
Publish
Society Ballot
Negatives
No
Yes
Acknowledged Within 30 Days
Subcommittee And Main Committee Considerations Of Negatives Not Previously Considered
Subcommittee and Main Committee Letter Ballots At Least ⅔ Affirmative Vote Required
Affirmed
Yes
No
Regular Or Special Meeting Of Subcommittee And Main Committee At Least ⅔ Affirmative Vote Required
Main Committee Ballot
Negatives
No
Yes
Acknowledged Within 30 Days
Subcommittee and Main Committee Considerations of Negatives Must Be Upheld by At Least A ⅔ Affirmative Vote Of Main Committee
If Procedural Delay Negative Judged Not Significantly Different From Negative Previously Ruled Not Persuasive Or Not Related In Subcommittee Ballot
Negative Withdrawn — Report This To The Main Committee
Subcommittee Position Upheld
Yes
No
Subcommittee Ballot
Negatives
No
Yes
Acknowledged Within 30 Days
If No Meeting Between Subcommittee And Main Committee Ballots
Main Committee Ballots Will Include Negatives Received On Subcommittee Ballot
Ruled Not Persuasive Or Not Related By At Least ⅔ Vote — Voter Must Be Notified
Negative Withdrawn
If Ballot Is Followed By A Meeting Of The Subcommittee
Subcommittee Consideration Of Negative Vote
Not Persuasive
Yes
No
Action Is Withdrawn And Returned To Originating Group
Subcommittee

APPENDIX F


Need for new standard
Subcommittee assigns project to task group
4-year review*
Hold until next publication
No
To an error in substance?
Yes
Task group study and preparation of draft for ballot, if indicated
Sub-committee ballot successful?
No
Yes
Substantive revisions suggested
Editorial changes
Publication
Main committee ballot successful?
No
Yes
Editing and production
Society ballot successful?
No
Yes
Committee on standards approval?
Yes
Adequate subcommittee response to cos?
No
Yes
No

APPENDIX G

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